MANPOWER COST ANALYSIS OF A DISTRIBUTED EN ROUTE SUPPORT STRUCTURE VERSUS A CONSOLIDATED EN ROUTE SUPPORT STRUCTURE

THESIS

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Abstract

The United States military has developed an en route support structure for airlift requirements to deploy and sustain combat forces in conflict. The Air Mobility Command (AMC) is interested in determining the cost effectiveness of two distinctly different en route structures, in particular, the cost effectiveness of one large facility versus supporting combat forces with many smaller facilities. With the current operational tempo, continued analysis must be accomplished to determine if a smaller footprint is possible in the deployment and sustainment scenarios of conflicts seen today; conflicts more centered on a leaner and faster deployment force. This research examines the requirements of manpower needed to support a network of one large facility and compares the data with the same information for a network of many smaller facilities. The number of required airfields in a distributed network must be determined to examine the manpower cost structure associated with the distributed network; therefore, the number of airfields becomes a cornerstone to which the cost analysis is predicated upon. The effectiveness of both systems will be measured in aircraft transits per day with the cost measured in annual manpower costs.

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To my family

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MANPOWER COST ANALYSIS OF A DISTRIBUTED EN ROUTE SUPPORT STRUCTURE VERSUS A CONSOLIDATED EN ROUTE SUPPORT STRUCTURE

I. Introduction

Background

Logistics plays an intricate role in sustainment of military operations, for without logistics, the soldier in the foxhole does not have the ammunition necessary to fire the weapon he or she holds. The complexity involved with delivering the right product, at the right time, to the right place can prove quite challenging. An already complex task interwoven into a complex environment can have serious impact on an organization, in this case, those men and women fighting on the front lines. According to Dye in *Understanding Public Policy*, the United States military is postured to fight two simultaneous wars in two distinctly different locations around the globe (2008:300). This policy held constant for many years, but as the 20th Century ended, a new policy was beginning to form. This policy, referred to as the "one-four-two-one" construct, was focused on defending the homeland first, effectively operate in four other strategic areas, fight in two nearly simultaneous combat operations, and win decisively in one of the two combat operations at the direction of the President (QDR, 2001). After the terrorist attacks of 2001, this strategy began to morph to a strategy similar to the *one-four-two-one* construct with a renewed emphasis on victory in the conflicts currently on-going, sustainment within these states, and a priority on the nuclear mission. The Quadrennial

Defense Review completed and published in 2010 states the defense strategies of today "…must balance resources and risk among four priority objectives" (2010). These objectives are "prevail in today's wars, prevent and deter conflict, prepare to defeat adversaries and succeed in a wide range of contingencies, and preserve and enhance the All-Volunteer force (QDR, 2010). These organizational factors, coupled with humanitarian efforts such as the tsunami relief in southeast Asia in 2004, piracy threats on the ocean, and now earthquake relief efforts in Haiti, are causing the military logistical problems that span a much broader area than just fighting on two battlefronts. This complex process in a highly complex environment lends itself to further analysis on ways to provide the same, if not better, sustainment while minimizing as much of the costs as possible.

From the birth of the United States Air Force in 1947 up until the end of the Cold War with the Soviet Union, the United States has relied on a "first-strike" deterrence when decisions were to be made on global support base positions (Lang, 2009:2). This thought process was conceived as a deterrent to other countries, as any first unconventional attack would be countered by a much stronger and ever-lasting counterattack (Hitch, 1960). With a strong presence in areas around the globe, the military has been afforded the opportunity to build an infrastructure to deter threats from others, serve as a defense force for allies, and support en route basing decisions for logistical purposes.

Roughly twenty years ago, the United States was faced with a significant drawdown after the Cold War with the Soviet Union ended. With this drawdown, the en route support system (ERS) has only 13 bases for use compared to the 45 bases seen in the early 1990s. Many military locations were closed and the associated personnel were transferred to bases in the continental United States, and as a result the bases that remain are now vitally important to the structure as the only means to move cargo and passengers into and out of war zones (GAO-01-566, 2001:9).

Figure 1 below from Sere's thesis, provides a look at the bases in Europe and Asia that serve as en route locations used today. These bases are situated to provide maintenance capabilities, crew staging, and refueling locations (Sere, 2005:1).

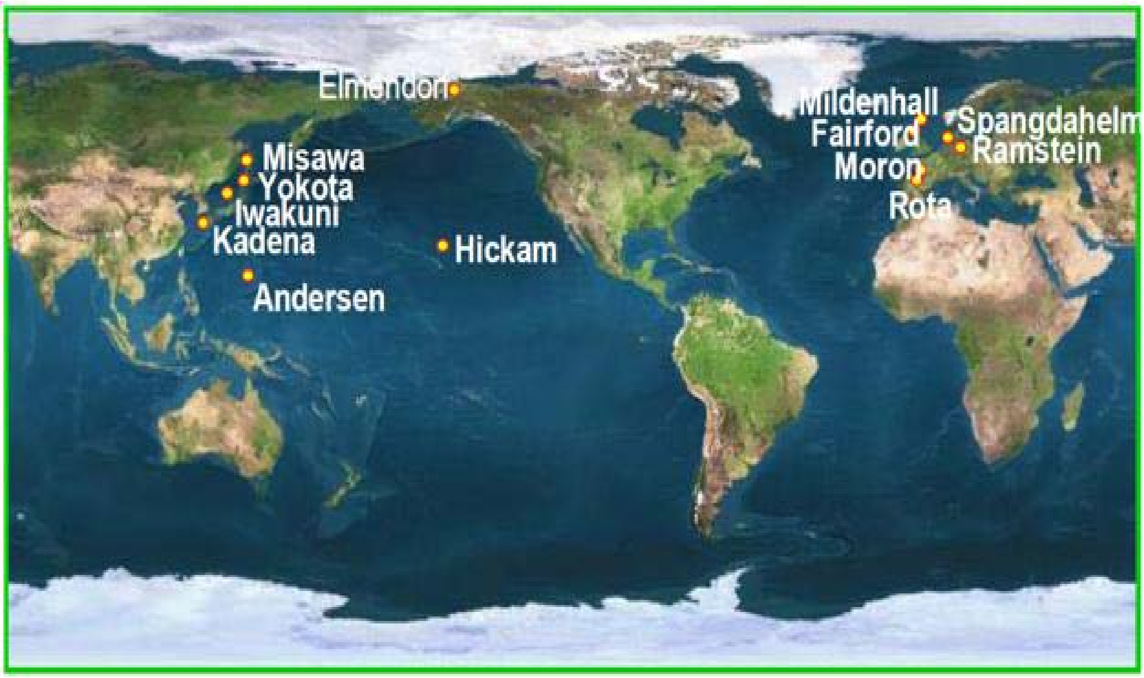


Figure 1: Current En Route Bases

Ramstein Air Base, Germany, had 470 aircraft transits in January of 2009. Aside from the primary bases considered in the area of operation (Middle East), the only base with more transits in the same month was Little Rock AFB, AR. Aircraft that depart from the United States, especially on the east coast, will often transit through Ramstein

AB due to its size, airlift mission, and presence. Figure 2 below is representative of a consolidated en route support system which would incorporate a large military presence to include the many support functions that would be necessary to support a base of this size. Inherent to a consolidated base like that of Ramstein AB, numerous support functions are required in order to sustain the primary missions. This would, in turn, result in large amounts of people located in one particular area. The capital expenditure up front is astronomical for a base of this size.

Figure 2: Consolidated Base at Ramstein AB

To counter this expenditure, the use of a distributed en route support structure that would utilize an already in place infrastructure may prove just as beneficial but at a much lower cost. This concept of a distributed network would result in a pre-defined number of bases used in a certain area, geographically separated but at no significant change in anticipated fuel burn. An example of a distributed en route support system is depicted by Figure 3 below.

The Air Mobility Command (AMC) and the United States Transportation Command (USTRANSCOM) are interested in analyzing the en route structure and continue to look for ways to improve the system and provide more flexibility and versatility at the same time. And at a time when the United States is spread thin between two wars and relief efforts around the world, this en route support structure must continue to be analyzed to adapt and change with current global conditions.

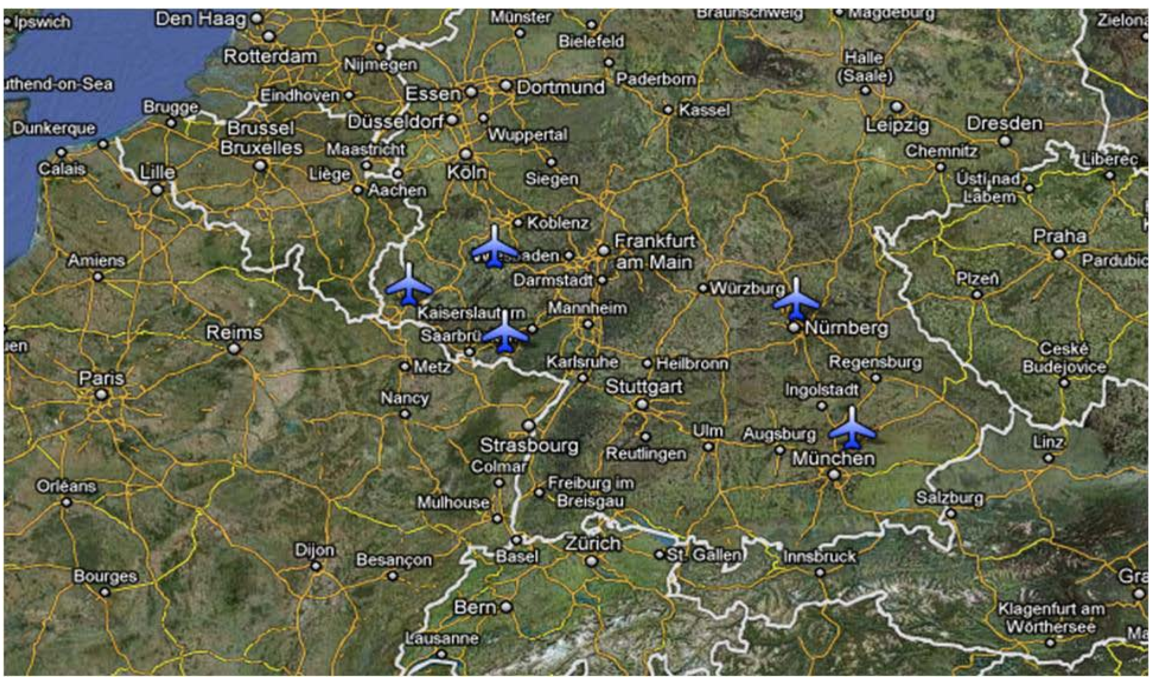


Figure 3: Example of a Distributed Network of Bases in Europe

Problem Statement

With the current force structure, coupled with the operational tempo that exists and the necessary logistical requirement to support forces, what is the most cost-effective means in terms of en route support systems to support the war fighter? Minimizing the cost is vitally important, but more important than that is the requirement to maintain a defined throughput capability to ensure the necessary items reach the foxhole from an initial location, often thousands of miles away. Therefore, the focus of this research is to examine the manpower cost associated with a distributed en route support system and compare it to a consolidated system through a cost analysis. For the purpose of this research, throughput capability is defined as the number of aircraft transits per day.

Research Question

For a more comprehensive examination of the research, several questions must be answered. The following questions are answered in order to provide a more thorough analysis:

- For a consolidated en route system comparison, what current base Unit Manning Document most closely resembles a specific airlift only mission?
- What operations will be supported by the distributed bases?
- Based on the operations supported, what will be the maximum aircraft on ground (MOG)?
- What Unit Type Code(s) would suffice for the distributed en route support system cost comparison?

The rest of this document is organized as follows. Chapter II presents the necessary and pertinent literature to this en route cost analysis. Chapter III explains the methodology used to approach this analysis. Chapter IV presents the results of the cost analysis through the use of the methodology. Finally, Chapter V provides conclusions and recommendations of the study.

II. Literature Review

Introduction

This chapter provides a review of the pertinent literature of en route structures and the strategy associated with them. A history of en route structures dating back roughly 20 year begins the chapter, followed by an overview of the literature that contributes to the analysis of throughput capability and the actual cost analysis of the required manpower. The chapter concludes with recent academic work in the realm of en route support structures.

The Current En Route Structure History

There has been much discussion on the ERS, in particular since the end of the Cold War when the United States drew down forces throughout Europe with base closures and realignments. The drawdown significantly reduced the flexibility that the 45 original ERS bases provided. Of these 45 bases, the drawdown closed the majority and only 13 ERS bases now remain. The Department of Defense selected these bases "according to their proximity to anticipated war zones, the host nation's willingness to allow the use of its bases, and other factors such as climate" (GAO-01-566, 2001:5). They were also planned according to the maximum efficient range of the C-17 aircraft without a refuel; a 3,500 nautical mile distance from the United States and the anticipated war zones (GAO-01-566, 2001:5). "The lens" concept incorporates the 3,500 nautical mile optimal range of a C-17 with 45 short tons of cargo (McVickar, 2002:14). According to a Graduate Research Paper authored by Jeanette Voigt, the lens is created by drawing two arcs; one from a coast in the United States 3,500 nautical miles away and the other arc originating from a point in a previously identified area of operation

(2005:6). The point of intersection then becomes the optimal location for en route facilities. In the European theater (which serves current operations in the Middle East and Southwest Asia) all six en route bases fall within this lens. The Pacific theater cannot adopt this strategy due to the geographical location of the United States in relation to Asia. Therefore two routes have been determined for en route airfields into and out of this theater: The Northern Pacific route through Alaska and the Middle Pacific route through Hawaii (Voigt, 2005:7). According to the GAO report, these bases are typically staffed for peacetime operations, and would normally require additional personnel and equipment to support contingency operations (2001:6); an important part of this analysis.

Desert Storm brought visibility to the fact that with the airfields that were currently in use, the system relied on a few key airfields, and thus the system was susceptible to delays attributed to weather and other unforeseen circumstances (McVickar, 2002:21). Concern mounted for the capability of the ERS as the demand requirements at these bases began to increase. Thus, the Air Mobility Command dubbed 1997 as the “Year of the En Route System” as an attempt to gain visibility and ultimately funding for the shortfalls in capability (GAO-01-566, 2001:2). With the new emphasis placed on the ERS, committees were formed in both the European Area of Responsibility (AOR) and the Pacific Area of Responsibility. By teaming with the United States Transportation Command, both AORs established their own committees, whereby the partnerships evolved into the European En Route Infrastructure Steering Committee (EERISC) and the Pacific En Route Infrastructure Steering Committee (PERISC) in 1998 and 1999, respectively. These committees serve mainly as forums to “research, identify, prioritize, and act on current and future en route infrastructure-related initiatives" (McVickar, 2002:20).

The EERISC developed a "six-lose-one" strategy in support of operations in Europe and Southwest Asia "in which all airlift flow would transit through any five of the six main European en route airfields" (McVickar, 2002:11). PERISC developed its own airlift strategy on what the EERISC had identified, and came up with two possible en route strategies to support efforts in Asia: one route through Hawaii and another transiting through Elmendorf, AK (McVickar, 2002:19). McVickar further states that along with identifying specific strategic routes into each AOR, the committees also identified areas within the infrastructure that required significant funding for improvements (2002:13).

With the ever-changing global environment, these en route strategies must be continually reviewed, modified, and updated on a recurring basis. According to a recent AMC White Paper discussing the Global En Route Strategy, "…we recommend that every two years, the command undertake a comprehensive review of the en route strategy." (White Paper). The author(s) cite many reasons for a newly defined global en route strategy, to include, but not limited to the following:

- "Significant manpower reductions as a result of the Program Budget Decision 720;
- The emphasis now placed on the Air Force Smart Operations for the 21st Century; mainly as a result of the reduction in manpower, no decrease in work and the desire to be more efficient. In economical terms, a reduction in the supply but an increase in demand;

- The establishment of Africa Command (USAFRICOM) and the competing mobility requirements associated with its establishment;
- The evolving nature of the battlespace that will likely be much more demanding of air mobility for deployment, supply, and redeployment;
- Advent of Just-In-Time Logistics concepts;
- The change in composition of the airlift fleet since the MRS-05 study" (White Paper)

According to the GAO-01-566 report, the Mobility Requirement Study 2005 (MRS-05) was released in 2001 as "an extensive update of DOD's 1992 and 1995 analyses of air, sea, and land transportation requirements for the United States to mobilize for war" (2001:2). The aim of this study was to estimate "the mobility assets and supporting infrastructure needed to deploy for the two war scenario and compared them to current capabilities and those planned for 2005" (GAO-01-566, 2001:6). This study reflected a shortfall in throughput capability of the 13 current en route airfields in the event of "overlapping theater wars". The exact requirements and the capacities associated with the ERS are classified and therefore not presented (GAO-01-566, 2001:6). For the MRS-05 study, a modeling approach was used, but the assumptions made are cause for uncertainty by the GAO. According to the GAO article, the net effects of the study are unknown because some of the assumptions may have underestimated the shortfall. The article mentions the assumption that some of these old and deteriorated ERS airfields will operate without breaking down, though the GAO did believe these underestimations would at least be partially offset by incorporating the "six-lose-one strategy" (2001:7). There is also cause for concern with the possibility of an overestimation with the model itself (2001:7).

The Department of Defense used a model named the Airlift Flow Model, whereby it simulates complex systems such as the ERS, and it "…does not necessarily identify the best or optimal solution to mobilization requirements" (GAO-01-566, 2001:7). According to the GAO report, the model continues to search for a solution through a simulation of cargo movements, but the solution generated may not be the optimal one (2001:7). Optimization models do exist, but the Department of Defense expresses reservation in the solutions that are provided, citing "that optimization models can come to unrealistic conclusions because they cannot simulate random events and may use information (such as longer-range plans for an entire mobilization) that may not be available to commanders early in the mobilization" (GAO-01-566, 2001:9). Regardless of the conclusions found with this study, the time in which it was completed was before significant events occurred in the global environment and therefore a re-examination of the overall ERS is a must. In a 2004 testimony before the House Armed Services Committee, then USTRANSCOM Commander General John Handy states that the European and Pacific en route projects have been implemented primarily due to the MRS-05 study and the established requirements. But he further states that in order to support on-going contingencies in the Middle East, additional infrastructure is required and is being studied by both the EERISC and the PERISC, moreover "…today's current operations, combined with existing studies, further demonstrate the need for expanded hazardous cargo capabilities at en route and theater airfields around the globe. To this end, USTRANSCOM is working with combatant commanders, Joint Staff, and DLA

(Defense Logistics Agency) to implement a truly global en route infrastructure system" (Handy, 2004).

Necessary Literature for Analysis

Significant use of military charts, documents, and pamphlets were used in order to better understand and complete the analysis. This literature is discussed in the following sub-headings as a better means for readability.

Throughput Capability

Regardless of the strategy used to determine the ERS, the requirement of most importance is the ability of the ERS to sustain the required throughput necessary to the AOR. For the purpose of this analysis, an examination of the cost associated with a consolidated ERS with that of a distributed ERS would require that the comparison be made with a calculated number of bases in the distributed system that would equal the throughput capability of the consolidated ERS. This analysis took a formula already defined and in existence from Air Force Pamphlet 10-1403 *Air Mobility Planning Factors* published in 2003 and modified it slightly for use. The pamphlet serves a vital role in the analysis of en route strategies in general, both for peacetime as well as in wartime operations by providing "…broad air mobility factors…" (AFPAM 10-1403, 2003:1). Further stated, "It is designed to help service, joint, and combined planners make gross estimates about mobility requirements in the early stages of the planning process" (2003:1). The formula below was the cornerstone in defining the distributed throughput capability:

$$Acft\ Transits\ per\ Day = \frac{(MOG)(Avg.Payload)(Ops\ Hrs)}{Ground\ Time} * (85\%\ QE)$$

A further description of each of the variables included in the formula is discussed in the following chapter, but for purposes of the literature review itself it is important to note that the maximum (aircraft) on ground (MOG) factor used coincide with the lower number associated with the working, the parking, and the fuel MOG (AFPAM 10-1403, 2003:5). As defined by the Air Force Pamphlet, MOG is literally the maximum number of aircraft which can be accommodated on the airfield (usually the parking MOG) (2003:25). The following list defines the aforementioned MOG definitions in AFPAM 10-1403:

- Working MOG: Maximum number of aircraft which can be simultaneously "worked" by maintenance, aerial port personnel, and others that potentially could be associated with the airlift mission.
- Parking MOG: Used synonymously with the general definition of MOG.
- Fuel MOG: Maximum number of aircraft which can be simultaneously refueled (2003:25).

For most ERS analyses, the throughput capability is a necessary determination to identify and locate any airfield which may pose a potential limiting factor (LIMFAC) in the planned ERS (AFPAM 10-1403:8). The pamphlet does make mention that for initial planning purposes, the assumption that all en route locations have higher throughput capability than that of the onload and offload locations (2003:8). While this initial assumption easily holds in the context of a consolidated ERS, for the distributed network of facilities, the assumption must be relaxed for a more accurate calculation of the likely number of bases required. For a different number of bases required, a more accurate depiction of the manpower costs associated with that system are required for analysis.

While AFPAM 10-1403 was the cornerstone for the formulation of the analysis, the Tanker Airlift Control Center (TACC) Planners Guide provided an initial MOG value for use in the analysis.

The TACC Planners Guide provides general and basic information related to a particular airport such as runway lengths, aircraft instrument approach procedures, and airfield operating hours. It also includes the MOG data used for the analysis, and in particular the formula derived from AFPAM 10-1403. This data is presented below in Figure 4. This figure provides an initial estimation of the MOG required for use in the formula, and since the contingency MOG is the same as the working MOG in this instance, no delineation is required for the purpose of this particular analytical example. The TACC Planners Guide is also extremely useful for the “operating time” variable, and per this guide, 22 hours is used due to the quiet hours mandate from 2200-0001 local time. This figure is presented in the next chapter.

MOG

Category	C130	C141	C17	C5	KC10	KC135	NBODY	WBODY
AMC PARKING	-	-	12	11	-	-	12	11
CONTINGENCY	-	-	4	2	-	-	4	2
WORKING	-	-	4	2	-	-	4	2

Change Information

Date: 09/30/05 13:30:54 User: mjleff0 Node: blwc50

Reason for Change: RMTP CONSTRUCTION

Parking MOG can be calculated by HQ AMC/CE on request, and provides a very rough estimate of MOG based purely on parking area available, assuming AMC uses all parking available.

Working MOG comes from TALCE teams, transcribed from an airfield survey. It shows how many aircraft can be handled at any time during peacetime operations, based on parking spots and equipment made available by the airfield manager or host nation.

Contingency MOG is determined based on discussions between the TALCE team commander and the airfield manager, and is based on an estimate of additional parking spaces and equipment (beyond those used in Working MOG) expected to be made available during contingency operations.

Figure 4: Excerpt from TACC Planners Guide for Ramstein AB, Germany

Manpower Cost Analysis

For the purpose of this study, the manpower cost associated with the two ERS systems is of importance and makes the analysis possible. Pay charts are necessary in order to determine the annual pay per rank, to include both military service members as well as DOD civilians. For the military, these are easily obtained but some of the civilian pay structures were more difficult to access. Those charts used are discussed further in the next chapter. AFI 65-503 *US Air Force Cost and Planning Factors* provides "…cost and planning factors that Air Force activities use to estimate resource requirements and costs associated with Air Force force structures, missions, and activities" (1994:1). The instruction actually caveats its own use by stating that the factors used "…are for general estimates" and should be combined or replaced with more specific or actual cost data when available (1994:1). For this analysis more specific data was used, mainly with the aforementioned annual pay per year per person charts for military service members and DOD civilians, though a supplemental tool was included within the analysis used for estimation purposes when specific manpower requirements are not known. The table used, from which the supplemental tool was formulated, is located in Appendix B.

There were a few documents necessary for review that are used to facilitate planning for mobility requirements. One particular document, the Air Force Contingency Response Group Operational Concept, was used in the initial analysis of what a distributed base might look like in terms of personnel required for a specific mobility mission. With the current deployment structure of the Air Force, specifically the Air Expeditionary Force concept, the document elaborates on the requirements "…to rapidly respond to contingencies as well as to secure and protect airfields, rapidly assess and open airbases, and perform initial airfield/airbase operations to ensure a smooth transition to subsequent operations" (Lee, 2004:1). This document was drafted as a means by which all Air Force Contingency Response Groups (CRG) will be standardized for easier employment where required to support the Joint Force Commander (2004:1). Lee delineated between different tiers of operation and defines them as "…five distinct modules that group combat, command and control, and expeditionary combat support together…" (2004:3). These five modules are listed below:

- "Open the Airbase"
- "Command and Control"
- "Establish the Airbase"
- "Generate the Mission"
- "Operate the Airbase" (2004:3)

Though this document serves a role more directly related to contingency operations and the initial employment of mobility forces, it does serve as another means by which to estimate the requirements for a distributed support system. Lee includes an agreed upon standardized package for use that includes the maintenance requirements and aerial port operations, which coupled with the Air Mobility Command Playbook identifies potentially useful data surrounding the question of what a distributed base would require in terms of manpower. This package became integral to the inclusion of certain UTCs for use in the study, and can be considered the backbone from which the decisions were made for manpower requirements at the distributed bases.

Recent Academic Work

With the Global War on Terror, continued throughput analysis is required especially as we see continued instability throughout the world. The likelihood now exists that the military will be responsible for not only the major theaters of war, but also the smaller contingencies that develop. On top of that, the supply of aid in the wake of natural disasters can be expected. For these reasons, there has been recent research to help develop tools and thought processes to aid decision makers in the en route support system. Although the current en route support structure does allow a great amount of flexibility within the continents of Europe and Asia, it does not allow for efficient transportation in other parts of the world.

Sere developed a goal programming based scoring technique to evaluate 25 potential enroute airfields in 8 geographical locations around the world (2005:75). These 25 potential airfields were identified by USTRANSCOM. Sere states that "the purpose of the goal program based methodology is to find the potential en route airfields which maximize the sum of the weighted percent deviations based on each goal and its associated weight" (2005:16). The goals associated with his analysis are the max critical leg of the route, the parking MOG at a particular airfield, the fuel capacity at the particular airfield, diplomatic relations with the country where the airfield is located, the proximity to a coastal seaport, and airfields within 2,250 miles of the en route airfield (Sere, 2005:16). The program identified three airfields within each of the eight geographical locations, which Sere stated can now be further evaluated in future research. Specifically, an evaluation of the throughput capability of airfields would be necessary to determine if these previously identified potential airfields could transit the required short ton capability to support the end customer.

Sere's research set an important foundation for Voigt's studies that centered more on the idea of analyzing throughput capability. Her research developed the Virtual Throughput Model (VTM) which "estimates the weight of cargo moved through an en route location daily" (Voigt, 2005:14). In Voigt's model, she further evaluated the airfields, as well as the actual geographic location for a more accurate estimation of an aircraft's cargo capacity at that particular location. Voigt posits that "runway length, air temperature, and pressure altitude all affect an aircraft's gross takeoff weight and therefore the amount of cargo it can carry" (Voigt, 2005:15). These factors can also combine complicating matters further. The distance traveled will dictate fuel burn, and will affect the amount of weight capable of airlift. But Voigt also incorporated the fact that a shorter distance traveled, equated to a lower altitude of flight which in turn burns more fuel.

Voigt's model evaluated the throughput from each pairing of the 14 potential en routes and eight destinations, "…creating a total of 112 en route/destinations pairs" (Voigt, 2005:22). She also ran her model based on three separate aircraft fleet mixes. Voigt found that each of the 14 potential airfields was a "top three provider" of throughput capability for a minimum of one destination (Voigt, 2005:48). With her analysis of the actual infrastructure in existence at the time of her research, Voigt states that because of military budget constraints, it would now be "efficient use of resources…" to invest in infrastructure improvements at all 14 locations (Voigt, 2005:48). Her final conclusion is that there are three en route airfields that are best to include as en route locations, based on cargo throughput capability (Voigt, 2005:48). Voigt recognized the importance of throughput capability, and therefore provided a means to further augment Sere's program.

Summary

There has been limited research in the realm of en route strategy, but what has been done has provided a strong foundation for the subject. Due to the military-specific nature of the subject, this may continue. However, AMC and USTRANSCOM continue to show interest in the research and have formed a partnership with the Air Force Institute of Technology that will continue to extend the necessary research and potentially provide answers to the important decisions regarding en route strategy. As for the research that has been done, a void exists in the costs associated with increasing the number of en routes compared to en routes already in place.

III. Methodology

Introduction

This chapter outlines the procedures used to analyze the manpower cost structure of a consolidated versus a distributed en route support system. Specifically, AMC/A9AA wanted to examine the possibility of replacing a large consolidated base with all of the supporting manpower allotments with a smaller network of bases that equaled the necessary throughput, but utilizing already inherent manpower specific to an existing airport (air traffic control, weather, etc.); thereby decreasing the required personnel to only those individuals necessary for a specific mission. In the case of this research, a refuel only mission is considered. Because of thorough analysis of the history of the en route support system strategy, as well as analysis of the current system, the procedures used to model the distributed system were possible. While the literature reviewed and previous studies have contributed to a broad understanding of the topic, there were a couple key offices within AMC that were integral to the completion of the study; they were the experts in the field and are mentioned throughout the methodology. To begin, the procedures used to develop the consolidated manpower analysis are discussed, followed by the analysis used to develop the distributed manpower cost analysis. Finally, a description of how throughput capability was incorporated into this study in order to better estimate the personnel associated with a distributed system, are discussed. This chapter concludes with a discussion of the assumptions and limitations used in this study.

Consolidated Manpower Analysis

Through discussions with Mr. Johnson and the AMC/A9AA office, the decision was made to forego the typical cost analysis regulation, *AFI 65-503*, as the data already exists to do a more thorough calculation of the manpower costs. As cited in Chapter II, *AFI 65-503* states that the calculations used are merely estimates as a means for initial planning factors, and should more specific data exist, the analysis should be conducted with the more specific and thorough data (1994:1). The average cost calculation described in *AFI 65-503* was included in the workbook model for further use in estimation should the inability to use actual data exist. A comparison was also done with the final numbers generated for both, and the comparison is discussed further in Chapter IV.

The AMC/A9AA office was heavily involved with the initial analysis phase of this research; a necessity since the question originated from the office, but also due to the expertise required in exactly how best to evaluate the en route system in this manner. While the model developed and the concept is not specific to a particular base or groups of bases, for a conceptual understanding, an example was provided in order to better describe the process. Ramstein AB, depicted and defined as one of the 13 current en route support bases, plays a vital role in the en route system. Ramstein AB is capable of providing the most throughput capability in the European theater, and therefore the base served as a focal point for the study. Ramstein AB, though a key base for en route studies, has a multitude of other functions associated with the base and therefore posed somewhat of a limitation on the manpower analysis. The analysis was completed to model only the en route capability mission, and not the other missions that may be included at a base. For this reason, the Unit Manning Document (UMD) for Ramstein AB would not suffice for the comparison since there would be no delineation between airlift only personnel and non-airlift personnel. The support personnel, for example finance, medical, and law, would all have positions staffed for the base in its entirety and therefore would prove problematic in the analysis. The AMC/A1MR office, in particular Dennis Miller, proved vital in providing information and expertise in the manpower realm. It was at this office where the UMD was obtained for use in the study, and it was this individual who provided a description of potential bases to use for the study, particularly the bases that currently have one mission, an airlift only mission.

According to Miller, Dover AFB, DE was the best base to model for an airlift only mission as the manpower requirements were of better use as compared to Ramstein AB; Charleston AFB, South Carolina; Travis AFB, California; and McGuire AFB, NJ. For that reason, the UMD for Dover AFB was used as the basis of the manpower cost comparison analysis of the consolidated en route support system. The UMD was reduced to only reflect the rank structure and the number of personnel authorized by the UMD for each rank. The UMD can be found in Appendix C. For clarification purposes, the UMD lists 27 allocations of a rank *to be determined*. These personnel slots were not included in the analysis, as there was no way to determine with any certainty the associated rank of these individuals. After determining the proper UMD to use for cost analysis purposes, the next step in the methodology was to calculate the annual pay rate for the grades listed in the UMD. The following formula was used to calculate the total annual pay associated with the study and is used throughout the study:

$$\sum_{i=1}^{n} APn * Xn \tag{1}$$

where

AP = calculated annual mean pay per rank n

X = the number of allotted slots per rank n

n = pay grade (to include military and civilian)

Military Pay Rate

The military pay scale used for this study was the Basic Pay Rate effective 1 January 2010. This scale can be found in Appendix D of this text. To take into account the time in service aspect of a military member's pay, the mean pay rate was calculated from the first day of service up to 22 years time in service. Year 22 was chosen as the cutoff as a rough estimate of the typical time an O-6 would have in the service; this assumption is further discussed at the conclusion of this chapter. After this calculation was made, the number was simply included in the workbook model and multiplied by the number of personnel at a particular grade in the UMD used for the study. The total number of personnel was tallied and the associated annual manpower cost was included, but this number was but a part of the overall comparison. The annual base pay was the only individual pay that was accounted for in this study as a way to capture the only assured income received by an individual. Basic Allowance for Housing (BAH) was not included due to the variability in the number itself: mainly the multiple locations conceivable, but also since the pay rate changes based on the number of dependents. There could also exist incentive pay depending on the location of the base. Assuming these en route bases would be located outside the country, family separation pay would have to be considered, as well as hostile fire pay, combat pay, etc. Due to the complexity and changing nature of the possibilities included with all other allotted payments, base pay was chosen as the only pay included in the study. The workbook then calculated the total number of personnel required in the system, as well as the total cost associated with the military service members. The UMD also had a large representation of civil servants included, and those calculations ensued.

General Schedule Pay Rates

Similar to the accessibility of the published military pay rates, the General Schedule (GS) pay scales are easy to obtain. Appendix E depicts the pay scale used. Similar to the way the annual pay rate was calculated for the military rank structure, the mean annual pay rate was formulated. The GS pay system, while not determined by years of service, has a similar structure in that pay increases within each rank. The pay increases within a rank are considered steps within the rank with equal increase amounts from GS-3 through GS-15. Due to the varying amounts of pay within the grades, the mean monthly pay was calculated for each GS rank and then multiplied by 12 months for the expected annual pay per rank. This number was then used to calculate the pay associated with each GS rank in the Dover AFB UMD. The annual pay was the only individual pay that was accounted for in this study due to the same reason as the military pay system with potential other allotted amounts of pay. After the individual ranks and the associated costs were tabulated, a simple calculation was included in the workbook to identify the total number of personnel required. The workbook also calculated the total manpower cost for the General Schedule employees to include in the final calculation in the workbook. Before the final calculation could be made, there were other pay scales requiring analysis.

Wage Grade Pay Rates

The Wage Grade (WG) pay rates were not as easy to obtain as the previous two pay scales, but the pay scale that was desired for use was found. The WG system provides the hourly rates associated with certain occupations throughout a base. It was found that the hourly rate varied from region to region as a means by which to account for the cost of living. For the purpose of this study, the pay scale associated with the Dover AFB, DE area was used. The data used for the analysis can be found in Appendix F but unfortunately the data was from 2009, as the 2010 pay structure has not yet been finalized. The pay structure resembles that of the GS pay system in that within each grade, there are multiple rates an individual can be paid. With the raw data as an hourly rate, the mean hourly rate calculated for each grade was taken and then multiplied by ten representing the hours of work per day multiplied by five for the number of work days in a week multiplied by 52 for the number of weeks in a year to obtain the mean annual pay per rank. This calculation was completed for the WG grades and then used to calculate the cost for that rank multiplied by the number of individuals at that rank based on the Dover AFB UMD. As before, after the individual ranks were calculated, the total number of personnel and the total cost associated with the WG employees was tabulated.

Other Pay Rates

As evidenced by the UMD in Appendix C, there are other civilian ranks to be considered in the analysis. In particular, the ranks preceded by a "Y". These ranks are a part of the National Security Personnel System (NSPS) and include the Standard Career Group, the Scientific and Engineering Career Group, Medical Career Group, and the Investigative and Protective Services. Of note, this pay system has since been repealed under 5 U.S.C. Section 9902 and while the positions are still recognized for pay purposes, by 2012 this system will be completely reverted back to the GS pay system "and cease to be effective" (2009). But since these positions are still incorporated within the UMD used for this study, the positions and the pay associated with them are still utilized in the analysis. This pay system is slightly different from the others, and hence the calculation was not the same. Per the NSPS Worldwide Pay Table, the base salary per year provided was a band with a minimum number and a maximum number. As each salary position varied with the minimum and maximum, the decision was made to take the mean of the two numbers with the result being the mean annual pay per salary position. With this calculation completed, the number was then implemented into the workbook and multiplied by the number of allotted positions for the position as defined by the Dover UMD, and then the total number of NSPS paid employees was calculated along with the total cost of these individuals.

The final calculation for the consolidated cost analysis was to sum up the total personnel required for the base and was merely the sum of the individual group sums. Likewise, the total manpower cost was calculated by simply taking the sum of the total annual pay calculations made for each pay system.

Distributed Manpower Analysis

The consolidated analysis was much easier to set up than that of the distributed analysis, mainly due to the fact that the consolidated base is already in existence and a UMD was readily available for use. For the distributed manpower analysis, a more thorough examination was required and the AMC/A9AA office was once again very helpful in providing the necessary data to make the research possible. The initial phase of this part of the research focused on the Air Mobility Command Playbook and the Air Force Contingency Response Group Operational Concept. Both support the analysis by providing background into the decisions required. Ultimately a Unit Type Code (UTC) was selected for the purpose of this en route analysis by the experts at the AMC/A9AA office.

Initial Phase

Multiple guides are in use for multiple scenarios in the mobility world, and for that reason, the analysis had to be designed around a specific problem in en route strategy. Initial estimates were based on generic packages not specifically tailored to any particular UTC. The first analysis considered a MOG 1 – 1 Shift operation depicted in Figure 5 on the following page. It provides the data associated with this analysis and comes from the AMC Playbook. This data provides the total number of passengers and cargo required to sustain aircraft, one at a time during a 12 hour work day. It further defines the personnel and cargo requirements by identifying organizations within a normal Wing construct (maintenance, aerial port, medical, etc.) and the required cargo necessary to perform their specific duties. This Playbook identified these same requirements for a multitude of other MOGs including shift operations, with the most demanding being a MOG 6 – 2 Shift operation that requires over 800 personnel (to include Security Forces). The breakdown in the Playbook also includes the airlift requirements to deliver both the passengers and the cargo for each scenario, which enhances the planning capabilities for the strategy. The variability in options allows for a multitude of possible analyses, especially a contingency type environment which is discussed later in this analysis as a possible research topic in the future.

UNCLASSIFIED

MOG 1 1 SHIFT

This plan will provide support for a mix of C-5 and C-141 aircraft operating out of a barebase location not to exceed a MOG of 1 / 12 Hour operations. Included is TALCE, Maintenance, Aerial Port, Security, Weather, Air Traffic Control, Crash Fire Rescue, Civil Engineering, Medical, Intelligence, and OSI. The package has been designed to self support for a 5 day period.

Assumptions for this package are as follows:

12 Hr Ops	Working MOG = 1 Strat
1 Shift	Ground Time: Normal
C-5 / C-141 Mix	Flow: 8 Aircraft per day
CFR: AMC provided	Weapons: Bulk shipped
MHE: AMC provided	Billeting: Tents AMC provided
MARC not provided	Pax plus bags = 300lbs

Totals:

With force protection		Without force protection*	
Pax:	476	Pax:	122
Pax weight:	71.4 St.	Pax weight:	18.3
Cargo:	685.41 St.	Cargo:	270.41
Total Weight:	756.81 St.	Total Weight:	288.71

Figure 5: AMC Playbook Excerpt of MOG 1 - 1 Shift Operation

In Chapter II, the Air Force Contingency Response Group Operational Concept was mentioned as the backbone for the selection of UTCs to include in the analysis. Figure 6 on the following page depicts a snapshot of a portion of Lee's contingency response group. This response group served as a baseline for the distributed analysis and the highlighted portions of the data include what could serve as a representation of the manpower required at a distributed base; note that the researcher is responsible for the highlights.

SPECIALITY	DESCRIPTION	UNIT TYPE CODE	NUMBER OF PERSONNEL
Assessment Team	Initial ADVON Team tasks accomplished within 24 hours of arrival	7E1AM or 9AADV (J-coded billets)	8
- Team Leader			
- Deputy			
- CE Officer			
- Airfield Operations			
- Security Specialist			
- Civil Engineering			
- Comm Technician			
- TBD			
TALCE	Ensure safe and efficient air base operation where AMC operational support is non-existent or insufficient		
- Aerial Port		UFBBS, UFBLB, UFBLD, UFBVP	17
- Aircraft Maintenance		HFHC1, HFHC2	13
- Mobile C2		7E1CA, 7E1AE	17
Security Forces	Force Protection	(2) QFEB2, QFEBS	31
Medical	Medical Care	FFGRL	4
OSI	Terrorist / espionage Security		1

SPECIALITY	DESCRIPTION	UNIT TYPE CODE	NUMBER OF PERSONNEL
Intel	Obtain, process, analyze, and disseminate intelligence information	(2) PF3MI	4
Ground Fuels	POL needs	JFA7M	1
Transportation	Ground transportation needs	UFMXC	2
Supply	Deployed supply needs	JFBFM	1
Comptroller	Deployed financial needs	XFFA2	1
ATC*	ATC NAVAID support	81ENV or conventional ATC equivalent	3 or conventional ATC equivalent
Contracting	Deployed contracting needs	XFFK7	1
COMM/INFO	Deployed Comm needs	6KNZ8	3
ATC*	ATC Combat Control Ops Flight	MOD-81 CCT or 81 AZT (draft) or conventional ATC equivalent	6 or conventional ATC equivalent
* ATC requirements are mission dependent, and may be provided by STT or conventional ATC units embedded with CRGs. In those instances, conventional ATC personnel/equipment will replace STT listed UTCs with a similar logistics footprint. Conventional UTCs are currently under development			
TOTAL NUMBER OF PERSONNEL			**113**

Figure 6: Portion of Lee's CRG Requirements

The highlighted areas of the document are what the researcher deemed possible minimum requirements at a distributed base. This later was tailored farther by the AMC/A9AA office to reflect the requirements of an en route refuel base only. The document prepared by Lee is extremely useful in that it allows a decision maker the ability to tailor a package as he or she deems necessary. With quick visual representation, the personnel required are defined, described, and numbered, and it also includes the actual UTC used to define these personnel. Again, the usefulness of Lee's document, which was approved by General John P. Jumper, the Chief of Staff at the time, provides the backbone for the distributed manpower analysis of this research and must be considered and reviewed for any future manpower analyses for the en route support system.

With the basis for the manpower requirements analyzed and understood, a more defined package was tailored to meet the specifications set forth by the AMC/A9AA office. Through that office, specific UTCs were selected and placed with a certain aircraft transits per day requirement as defined by the researcher. There were five UTCs selected for further examination: 7E1AF, 7E1AE, HFHC1, HFHC2, and 7E1AN:

- ***7E1AF***: designed to "…manage, monitor, and control aircraft ground ops for working MOG of one. UTC is capable of 24-hour coverage but limited to 12 hour ops." It includes a total of four personnel: one 7-level in-flight refuel craftsman, one 7-level aircraft loadmaster craftsman, one 5-level aircraft loadmaster journeyman, and one 5-level RF transmission systems journeyman.
- ***7E1AE***: designed to "manage, monitor, and control aircraft ground operations for working MOG of 12 or less, capable of sustained 24-hour-a-day command and control support operations during deployment and redeployment." It includes a total of 11 personnel; three officers and eight enlisted. Three general mobility airlift pilots with two Captains and one Major, one 7-level in-flight refuel craftsman, one 7-level aircraft loadmaster craftsman, one 5-level aircraft loadmaster journeyman, two 7-level command post craftsman, one 5-level command post journeyman, one 5-level airfield management journeyman, and one 5-level personnel journeyman.
- ***HFHC1***: Considered an independent UTC that "…provides quick turn maintenance for maximum on ground (MOG) of one to two C-5/C-17 aircraft in a 12-hour day 247 man-hours per month basis". This UTC provides the minimum number of maintenance personnel with the capability of ground handling and

servicing, towing, and performing a tire change to support an established command and control element. The maintenance team has the red-x downgrade authority along with an all-systems red-x sign off capability and in-process inspection qualification. The team has a total of six members; two 7-level aerospace maintenance craftsmen, three 5-level aerospace maintenance journeymen, and one 9-level aerospace maintenance superintendent. Should the desire exist to increase the operation from 12 hours to a 24 hour operation, this UTC can be augmented by the HFHC2 UTC.

- ***HFHC2***: Considered a dependent UTC that "…provides quick turn maintenance for maximum on ground of one to two C-5/C-17 aircraft in a 24-hour day, 247 man-hours per month basis". Similar to the HFHC1 UTC, it provides the minimum number of maintenance personnel to support ground handling and servicing, tire changes, and aircraft tows in support of an established command element. If a specialist UTC is included as augmentation, it will increase the working MOG by two. This UTC also maintains the red-x downgrade authority, the all-systems red-x and in-process inspections qualifications. This UTC has a total of 7 personnel; one Major aircraft maintenance officer, three 7-level aerospace maintenance craftsmen, three aerospace maintenance journeymen.
- ***7E1AN***: This UTC is required for aircrew stage management and "…is used to manage aircrew stage operations. Can stand alone or augment mobile, fixed, or enroute command and control." It is capable of 24-hour operations. In total, there are four individuals included in this UTC; two generalist pilots with one

being a Major and the other a Captain, one 7-level aviation resource management craftsman, and one 5-level aviation resource management journeyman.

- ***HFC05/HFHC17***: These UTCs serve to augment the HFHC1 UTC (each of these is airframe specific to either the C-17 or the C-5 aircraft) with the capability for repair and reclamation capabilities for a MOG of one in a single shift operation. Either UTC can also augment the HFHC2 UTC to increase the MOG to four in a two shift operation. Each has the same personnel requirements and include one 7-level, B-shop integrated avionics system craftsman, one 5-level, B-shop integrated avionics system journeyman, one 7-level, A-shop integrated avionics system craftsman, one 5-level, A-shop integrated avionics system journeyman, one 7-level aerospace propulsion craftsman, one 5-level aerospace propulsion journeyman, one 7-level aircraft hydraulic systems craftsman, one 5-level aircraft hydraulic systems journeyman, one 7-level aircraft electrical and environmental craftsman, and one 5-level aircraft electrical and environmental journeyman. This UTC requires 10 individuals.

With the UTCs identified for use in the study, the conversion into the workbook cost analysis tool was the next step. Due to the structure of the UTC, assumptions were required in order to model the actual grade of the personnel since the UTC only provides the technical skill set required. This technical skill set (7-level, 5-level, etc.) was converted to a specific grade for the purpose of analyzing the costs further, with a more conservative approach taken. For the purpose of this study, the researcher assumed that a 7-level would be considered an E-6 and a 5-level would be considered an E-5. This does not mean that in actuality a 7-level associated with a certain UTC must be a Technical Sergeant, nor a 5-level a Staff Sergeant, but to take a more conservative approach to model the annual cost of personnel, this approach was deemed sufficient and necessary.

With the UTC information gathered, analyzed, and converted for use in the workbook, the same calculations as the consolidated analysis were used. By simply taking the mean annual pay per grade and multiplying by the number of personnel within that grade, the calculation obtains the total annual manpower pay per distributed base. For the distributed base calculation, an additional calculation was required in order to obtain a true representation of how many bases are required to sustain the aircraft transits per day that an otherwise consolidated and much larger base could handle. The next sub-section further defines the formulation for throughput capability as used in this analysis, but for now, suffice it to say that the total number of personnel required at one distributed base is then multiplied by the number of bases required for sustained capability. This calculation allows for the total number of personnel required throughout the distributed base network, and likewise the total annual manpower pay of those personnel.

Throughput Capability Incorporation

The war fighter is the end-user and customer of the airlift into the theater, and for that reason, the throughput capability at the distributed bases had to equal what already exists at a consolidated base. This comparison then answered the main question of this research. But in order to obtain those numbers, an analysis was required on the throughput capability, in this case aircraft transits per day, for an accurate representation of the network in its entirety. The calculation for throughput capability found in

AFPAM 10-1403 was used as the cornerstone for the formulation in this process and is found below:

$$ATC = \frac{(MOG)(Avg.Payload)(Ops\ Hrs)}{Ground\ Time} * (85\%\ QE) \tag{2}$$

where

ATC = Aircraft Throughput Capability (measured in short tons)

MOG = Aircraft Maximum on Ground

Avg. Payload = Average aircraft payload measured in short-tons

Ops Hours = Time, in hours, aerial port is open

Ground Time = Mean aircraft ground preparation time in hrs

QE = Queuing efficiency of operation

Through discussions with the AMC/A9AA office, the decision was made that the above formula would be altered for the purpose of this study for a more general use in this research. Average payload was removed to form a new derivation of this formula to generalize the number of aircraft transits per day without having to identify the specific type aircraft required and the amount of cargo moved. This incorporates a new unit of measurement more conducive to this research, labeled number of aircraft transits per day (*ATPD)* rather than Formula (2) whereby the dependent variable is measured in short tons. All other variables remained the same, and the workbook was modeled to account for these variables as they relate to both the consolidated and the distributed network. The new formula used for this analysis is defined on the following page:

$$ATPD = \frac{(MOG)(Ops\ Hrs)}{Ground\ Time} * (85\%\ QE) \qquad (3)$$

where

ATPD = Number of Aircraft Transits per Day

MOG = Aircraft Maximum on Ground

Ops Hours = Time, in hours, aerial port is open

Ground Time = Aircraft ground prep time, in mean hrs

QE = Queuing efficiency of operation

The TACC Planners Guide and *AFPAM 10-1403* were used to enumerate the variables of the above formula. The TACC Planners Guide was incorporated for the two variables in the numerator, MOG and Ops Hrs. *AFPAM 10-1403* was used to define the denominator and is located in Appendix A. The 85% queuing efficiency was deemed appropriate. Historically, planners and strategists have included this factor in certain formulas "…to account for the physical impossibility of using limited airfield facilities with perfect efficiency" (AFPAM 10-1403, 2003:26). A simple example was provided by *AFPAM 10-1403* and posited that an aircraft parking spot is never instantly occupied after it is vacated (2003:26). The researcher chose 85% for use in this analysis due to its pre-existing acceptance. Table 1 on the following page depicts the actual workbook formulation for analysis. The numbers are explained in more depth to provide an example as to how the aircraft transits per day required for the distributed en route strategy were incorporated into the associated manpower costs. The line titled *MOG* represents the defined MOG capability in existence at a particular airfield, as well as the MOG desired for the airfields included in the distributed support system. For this example, a MOG of four was used for the consolidated base whereby four was selected from the TACC Planners Guide as the working contingency MOG for C-17 aircraft at Ramstein AB, Germany. For conservative planning, the researcher chose to model a 24-hour aerial port operation though the TACC Planners Guide reported a 22-hour operation due to noise restrictions at night. The ground time, as defined by *AFPAM 10-1403* for refuel and go operations of C-17 aircraft was modeled at 2.25 hours. Queuing efficiency was modeled at 85% due to the impracticality of a 100% efficient operation. Using Formula (3), the mathematical calculation resulted in 36.267 aircraft transits per day for the consolidated support system.

Table 1: Throughput Capability Calculation Example

	Consolidated	Distributed	Number of Distributed Bases Required:
MOG	4	1	10
Ops Hrs	24	10	
Ground Time	2.25	2.25	
Queuing Efficiency	0.85	0.85	
Acft Transits per day	36.267	3.778	

For the distributed support system, the AMC/A9AA office desired to model the most simple of airfield requirements with minimal manning. A MOG of one was selected with a one-shift per day operation of 10 hours. The ground time was kept at 2.25 hours based off of the refuel only requirement for C-17 aircraft defined by *AFPAM 10-1403*, and the queuing efficiency remained at 85% as before. Using the same formula as the consolidated system, the calculation resulted in 3.778 aircraft transits per day. An additional calculation then remained to account for the approximate 9 fold difference in aircraft transits per day. By dividing the number of aircraft transits per day of the consolidated system by the number of aircraft transits per day of the distributed system, the calculation resulted in a 10-base (due to decimal point rounding within the workbook calculation for a realistic number of airfields) requirement for the distributed network of support bases in order to equal the required throughput capability (or in this case, aircraft transits per day) of the larger consolidated base.

Final Calculation

The result from the above example of 10 bases in the distributed network was then included in the final calculation to obtain the estimated manpower total mean cost per year of the distributed network. This number was then multiplied by the total annual manpower pay for one distributed base and by the total number of personnel required. These final numbers were used to compare the manpower numbers and costs of the consolidated base versus the distributed bases of the en route support system.

Assumptions and Limitations

This section lists the assumptions and limitations of this research that were deemed necessary for the analysis' completion. None are so grave that a non-valid research analysis is warranted, but nonetheless assumptions and limitations must be mentioned for any future modifications or changes. The following are the assumptions for this work:

1) The UMD from Dover AFB resembles the UMD of any consolidated en route airbase.

a. The lieutenants authorized are split in half amongst the grades of O-1 and O-2

2) The particular UTCs used for the distributed en route system analysis, specifically 7E1AE, 7E1AN, HFHC2, are accurate and realistic depictions of manpower requirements to sustain refuel only operations at a distributed field.
3) The rank of Technical Sergeant (grade of E-6) was used to model a 7-level technician as required by the UTCs mentioned in assumption 2.
4) The rank of Staff Sergeant (grade of E-5) was used to model a 5-level technician as required by the UTCs mentioned in assumption 2.
5) Max amount of time spent in military service was 22 years. This allowed for ease in calculating the mean annual pay per grade.
6) Prior-enlisted officers are not allocated within the Dover UMD, to allow for ease in calculating the mean annual pay per grades O-1 through O-3.
7) A queuing efficiency of 85% sufficiently models the expected efficiency in the day-to-day operations of an aerial port.
8) The model assumes an unlimited number of airfield locations in a certain geographic region that the Department of Defense is capable of selecting for the distributed network.
9) The UTCs selected for use assume that all other required manpower resources for airfield operations is inherent to the airfields selected for inclusion in the distributed network.
10) One shift equals 10 hours of work.

11) Aircrew personnel from an arriving aircraft are replaced by another crew with the required crew rest, and the aircraft then departs the airfield.

The limitations of the research are just as important to discuss as the assumptions, mainly to provide a better understanding for those, who may in the future, choose to further this research. As mentioned previously, the manpower costs are not complete and only include the base pay associated with a particular grade; military service members as well as civilians. If the geographic area of the distributed network were known, a better cost estimate is possible given the basic allowance for housing could be included in the estimate. The other allotted pay amounts would also be known and could be included. The UTCs used in the research provide only minimum personnel requirements to support a gas-and-go operation. Therefore, another assumption and limitation posed by this research is that no aircraft within the network would ever require maintenance. Lastly, the UTCs chosen for this research are strictly for gas-and-go operations and require further analysis if the desire exists to bolster capabilities at these particular en route bases. These points are discussed in a later chapter as they relate to future research ideas.

IV. Results and Analysis

Introduction

The versatility of the workbook developed for use in the manpower cost analysis allows for multiple comparisons. Chapter III presented the methodology and this chapter presents a few different comparisons of expected scenarios in developing en route strategies. Furthermore, with the limitations of this research discussed in Chapter III, the UTCs previously selected for analysis remain the cornerstone of the analyses presented in this section. The analyses include a comparison of a one shift operation and that of a two shift operation with a MOG of one requirement for the distributed network of en route support airfields. The analysis also includes a MOG of four with a two shift operation to model a more bolstered en route distributed support system that incorporates maintenance and supply elements. In all situations, a crew staging UTC (7E1AN) is used for the assumption that the aircraft always depart an en route airfield the same day of arrival as long as the aircraft is mission-capable. The 7E1AN UTC allows for crew staging management and overall supervision and scheduling of crews during changeover due to crew rest requirements as defined by the military and the Federal Aviation Administration (FAA). To conclude this section, a brief comparison is presented with regards to the total manpower costs associated with a particular manpower analysis related to this research compared to the cost analysis that would develop from using the average cost per officer and enlisted member used by *AFI 65-503*. The personnel required for the MOG 4 – 2 Shift operation of a distributed network is used for the cost analysis developed from *AFI 65-503*.

MOG 1 – 1 Shift Operation

The primary research question posed by the AMC/A9AA office was what the total manpower cost of a single shift operation throughout a network of distributed bases would be in comparison to a consolidated en route support base. For this reason, the formulation was setup based on a single shift operation (in this scenario one shift equaled 10 operational hours) that supported a MOG of one. Table 2 below is a snapshot from the workbook tool used in the formulation.

Table 2: MOG 1 - 1 Shift Aircraft Transits Per Day

	Consolidated	Distributed	Number of Distributed Bases Required:
MOG	6	1	13
Ops Hrs	22	10	
Ground Time	2.25	2.25	
Queuing Efficiency	0.85	0.85	
Acft Transits per day	49.867	3.778	

The column labeled *Consolidated* represents the data that corresponds to Ramstein AB, Germany as defined by the *TACC Planners Guide*. The working MOG associated with Ramstein AB included 4 C-17 and 2 C-5 aircraft for a total MOG equal to six as depicted in the row titled *MOG*. The operational hours are again taken from the *TACC Planners Guide* and equal 22 due to the two hours of quiet hours from 2200-2400. The ground time of 2.25 hours is based on data from *AFPAM 10-1403* for en route refuel only and the queuing efficiency of 85% is included in the formulation as a previously accepted standard used in modeling efficiency levels. The number of aircraft transits per day is calculated by using Formula (3) with the final number for Ramstein AB under the above stated parameters equal to 49.867 aircraft transits per day.

The column labeled *Distributed* reflects the parameters set by the AMC/A9AA office to identify the minimum personnel requirements for a distributed network of bases to replace a consolidated base as identified in the paragraph above. In this case, a working MOG of one is used under a single shift operation of 10 hours per day. The ground time remains the same at 2.25 hours as defined by *AFPAM 10-1403* with the same queuing efficiency of 85%. By using Formula (3), the number of aircraft transits per day equates to 3.778 aircraft transits per day for one base within the distributed network of en route bases. In carrying out the final calculation to obtain the total number of distributed bases needed to equate the total aircraft transits per day provided by a consolidated base, the aircraft transits per day from the consolidated base is divided by the number of aircraft transits per day from the initial distributed network calculation. For this scenario, dividing 49.867 (consolidated throughput) by 3.778 (distributed throughput for one base) the total number of distributed bases required for the en route support network is 13 (realistic number after rounding). With the throughput calculation completed and the total number of distributed bases required for the network known, the total manpower cost associated with the network can be determined.

For the manpower associated with this analysis, the following UTCs were used: 7E1AF, 7E1AN, and HFHC1. These UTCs represent the minimum manpower requirements needed to support refuel only operations for a single shift (10 operational hours) and a MOG of one. Table 3 lists the grades of the individual requirements as set by the aforementioned UTCs.

Table 3: MOG 1 - 1 Shift Distributed Manpower

	E-3	E-4	E-5	E-6	E-7	O-3	O-4
# of Personnel			6	5	1	1	1
Annual Pay Rate	$0	$0	$192,634	$182,859	$42,104	$63,504	$71,949
Total Annual Pay	$553,050						
Total # of Personnel	14						
Total Manpower Pay Including All Distributed Bases			$7,189,646				
Total # of Personnel Including All Distributed Bases			182				

Table 3 depicts a total of 14 individuals required at a total annual cost for one base in the system of $553,050. To obtain the total cost of the entire distributed network of en route bases, these numbers must be multiplied by the number of bases required in the system to equal the total aircraft transits per day of a consolidated base; in this case it would be Ramstein AB. These calculations are 182 total individuals at a total mean annual cost of $7,189,646 for the entire distributed system.

To compare these numbers to the consolidated en route support system, Dover's UMD was used with the calculations listed on the next page in Table 4. Table 4 calculates the total manpower cost of the consolidated en route airfield (Dover AFB UMD) to include the military service members and the civilians. There are a total of 3,223 military service members at a cost of $107.7 million. The General Schedule (GS) personnel total 287 members at $11.5 million, the National Security Personnel System (NSPS) wage grades total 147 people with a cost of $9.6 million, and finally the hourly employees within the WG grades total 268 people at an annual cost of approximately $18.3 million. The total number of personnel defined by the UMD is 3,925 personnel with a mean annual cost of $147.2 million.

Table 4: Total Required Consolidated Manpower

	E-3	E-4	E-5	E-6	E-7	E-8	E-9	O-1	O-2	O-3	O-4	O-5	O-6
# of Personnel	721	682	754	461	252	39	22	43	43	109	51	40	6
Annual Pay Rate	$16,420,165	$18,139,584	$24,207,646	$16,859,621	$10,610,262	$1,990,310	$1,322,040	$1,730,557	$2,167,164	$6,921,906	$3,669,387	$3,183,618	$535,909
Total Annual Pay	$107,758,171												
Total # of Personnel	3223												

	GS-3	GS-4	GS-5	GS-6	GS-7	GS-8	GS-9	GS-10	GS-11	GS-12
# of Personnel	5	59	47	14	40	12	69	4	34	3
Annual Pay Rate	$125,580	$1,663,476	$1,482,568	$492,275	$1,563,100	$519,288	$3,297,890	$210,552	$1,966,186	$207,944
Total Annual Pay	$11,528,858									
Total # of Personnel	287									

	YA-02	YB-01	YB-02	YC-01	YC-02	YC-03	YD-01	YD-02	YF-02	YF-03	YH-02	YN-01	YM-01
# of Personnel	48	2	5	7	31	1	1	10	8	1	7	9	17
Annual Pay Rate	$3,212,880	$57,180	$231,938	$345,244	$2,706,672	$109,460	$46,115	$669,350	$698,496	$107,764	$527,797	$443,885	$486,030
Total Annual Pay	$9,642,808												
Total # of Personnel	147												

	WS-03	WS-04	WS-05	WS-06	WS-07	WS-08	WS-09	WS-10	WS-11	WS-12	WS-13	WS-14	WS-15
# of Personnel	1	4	1	3	1	10	9	5	5	1	0	1	1
Annual Pay Rate	$65,827	$279,864	$74,116	$234,702	$82,160	$851,032	$792,324	$453,856	$464,854	$95,945	$0	$102,539	$106,210
Total Annual Pay	$3,603,428												
Total # of Personnel	42												

	WL-08	WL-10	WG-03	WG-04	WG-05	WG-06	WG-07	WG-08	WG-09	WG-10	WG-11	WG-12
# of Personnel	6	12	27	0	7	15	12	27	9	87	10	14
Annual Pay Rate	$420,389	$919,838	$1,199,578	$0	$368,987	$852,384	$728,957	$1,720,321	$603,486	$6,067,136	$723,944	$1,051,523
Total Annual Pay	$14,656,543											
Total # of Personnel	226											

Total Annual Pay	$147,189,808
Total # of Personnel	3,925

**Data represents the current Unit Manning Document from Dover AFB

The workbook incorporates another spreadsheet for a much simpler representation for the comparison and is depicted in Figure 7 on the following page. It provides rapid visibility of the exact comparison of the two en route systems analyzed. For the MOG 1 – 1 Shift scenario, the distributed system uses 3,743 less personnel, and the personnel cost is approximately $140 million less than the consolidated en route system. Figure 7 also depicts the aircraft transits per day for each system to identify the capability easily without having to change tabs within the workbook.

Figure 7: MOG 1 - 1 Shift Quick Comparison

MOG 1 – 2 Shift Operation

The first set of results is for a very basic representation of a distributed network as prescribed by the AMC/A9AA office. For this research, a second analysis was conducted to compare the calculations of a MOG 1 – 1 Shift operation to that of a MOG 1 – 2 Shift operation. The same process was used as before, with the first calculation being the aircraft transits per day identifying the specific number of distributed bases required in the network. These calculations are represented in Table 5 on the following page.

Table 5: MOG 1 - 2 Shift Aircraft Transits Per Day

	Consolidated	Distributed	Number of Distributed Bases Required:
MOG	6	1	7
Ops Hrs	22	20	
Ground Time	2.25	2.25	
Queuing Efficiency	0.85	0.85	
Acft Transits per day	49.867	7.556	

Table 5 used the same parameters as the MOG 1 – 1 Shift operation: a MOG of 6, aerial port operations of 22 hours defined by the *TACC Planners Guide*, 2.25 hours of ground time for refuel only purposes defined by *AFPAM 10-1403*, and the historical standard of 85% for the queuing efficiency. The number of aircraft transits per day in the consolidated network remained at 49.867. The distributed network parameters were changed slightly. The MOG of one remained the same, as well as the 2.25 hours of ground time and the queuing efficiency of 85%. The change was made to the operational hours incorporated into this analysis. One shift equals 10 hours for the purpose of this research, and since these results are predicated on a two shift operation this number was increased to 20. The throughput calculation of the distributed network resulted in 7.556 aircraft transits per day per base. For the entire network to support the total number of aircraft transits per day within the consolidated system, the distributed network must include at least seven bases. After obtaining this number, the distributed network personnel requirements can now be examined.

The UTCs required for a two-shift operation and a MOG of one are 7E1AE, 7E1AN, HFHC1, and HFHC2. While similar to the first analysis for a single shift operation, there were a few necessary changes. The 7E1AF UTC was replaced with 7E1AE, and HFHC2 was added to augment HFHC1 for a two shift operation. The numbers are illustrated below in Table 6.

Table 6: MOG 1 - 2 Shift Distributed Manpower

	E-3	E-4	E-5	E-6	E-7	O-3	O-4
# of Personnel			11	10	1	3	3
Annual Pay Rate	$0	$0	$353,162	$365,718	$42,104	$190,511	$215,846
Total Annual Pay	$1,167,342						
Total # of Personnel	28						
Total Manpower Pay Including All Distributed Bases			$8,171,395				
Total # of Personnel Including All Distributed Bases			196				

The manpower requirements for a distributed network in a MOG 1 – 2 Shift operation totals 28 personnel at a total mean annual cost of $1,167,342 million for a single base. By incorporating the first calculation that determined the number of bases required to equate to the 50 aircraft transits per day of a consolidated base, the grand total comes to 196 personnel at a mean annual cost of $8,171,395 million.

The consolidated requirements are exactly the same as the first analysis in this chapter; therefore, refer to Table 4. For a quick depiction of the comparison of this study refer to Figure 8 on the following page. It provides a quick visualization of the actual comparison of a consolidated network to that of a distributed network. The consolidated numbers have not changed from the previous analysis, but by changing the shift operation from one to two (20 operational hours), personnel numbers have increased but are still 3,729 fewer personnel requirements than the consolidated. The total mean annual cost has also increased from the first analysis, but it still is less than the consolidated cost by approximately $139 million while maintaining the required 50 aircraft transits per day.

CONSOLIDATED

Total Personnel	Total Annual Cost	Aircraft Transits Per Day
3,925	$147,189,808	50

DISTRIBUTED

Total Personnel	Total Annual Cost	Aircraft Transits Per Day
196	$8,171,395	50

Figure 8: MOG 1 - 2 Shift Quick Comparison

MOG 4 – 2 Shift Operation

The purpose of the analysis of a MOG 4 – 2 Shift operation is to provide a decision-maker with additional information on what a distributed network of bases could provide for above and beyond the very minimal manning, but still far less than that of the consolidated network of bases. The MOG 1 -2 Shift operation serves as the baseline comparison for the MOG 4 – 2 Shift analysis. The HFC17 UTC enhances a two shift operation's MOG capability to four with a minimum of additional personnel. The HFHC2 UTC states that by augmenting with the HFC17 UTC (total of 10 individuals), an operation has the enhanced capability for maintenance troubleshooting and repair of certain discrepancies and malfunctions. This package does require additional supply support, in particular a spare parts kit and additional supply personnel. Specifically, HFC17 UTC requires a supply personnel UTC (JFxxx) to augment this enhanced capability. Therefore, the researcher chose to include the JFBAC UTC that provides a supply function and capability to establish connectivity to the Air Force's supply system. This is not a standalone UTC and for this reason the JFBMR UTC was added for the capability to receive, source, and issue parts as necessary. In total, these last two supply-function UTCs include four additional individuals for one base; two 7-levels and two 5-levels.

Table 7 on the following page depicts the throughput calculations required to obtain the number of aircraft transits per day and the final number of bases required in the distributed network. As with the calculations included in the previous analyses, the consolidated system numbers remain the same with a MOG of 6, 22 hours of operational time, 2.25 hours of ground time, and a queuing efficiency of 85%. Again, the calculation equates to 49.867 aircraft transits per day.

The distributed network can now be tabulated and used for comparison to the consolidated system, as well as the previously analyzed distributed network with a MOG of one. The calculation for the distributed system changed to a MOG of four due to the enhanced UTC packages, with a two shift operation that is equal to 20 hours of operational time. The ground time and queuing efficiency were the same as before, with the calculation obtaining 30.222 aircraft transits per day that amounts to two bases in the distributed network.

Table 7: MOG 4 - 2 Shift Aircraft Transits Per Day

	Consolidated	Distributed	Number of Distributed Bases Required:
MOG	6	4	2
Ops Hrs	22	20	
Ground Time	2.25	2.25	
Queuing Efficiency	0.85	0.85	
Acft Transits per day	49.867	30.222	

For the manpower calculations for the distributed network for a MOG of four and a two-shift operation, the UTCs described at the beginning of this analysis were used. Table 8 below depicts the personnel requirements associated with each of the aforementioned UTCs. For one base in the distributed network, the total personnel required for full operation with the 7E1AE, 7E1AN, HFHC1, HCHC2, HFHC17, JFBAC, and JFBMR UTCs is 42 people at a total mean annual cost of approximately $1.648 million. To equal the throughput capability of the consolidated base of 50 aircraft transits per day, the distributed network requires two bases with each containing 42 people. This comes to a grand total for the distributed network of 84 people at a total mean annual cost of approximately $3.296 million.

Table 8: MOG 4 - 2 Shift Distributed Manpower

	E-3	E-4	E-5	E-6	E-7	O-3	O-4
# of Personnel			18	17	1	3	3
Annual Pay Rate	$0	$0	$577,901	$621,721	$42,104	$190,511	$215,846
Total Annual Pay	$1,648,084						
Total # of Personnel	42						
Total Manpower Pay Including All Distributed Bases			$3,296,169				
Total # of Personnel Including All Distributed Bases			84				

The consolidated requirements are exactly the same as the first analysis in this chapter; therefore, refer to Table 4. For a quick depiction of the comparison of this study refer to Figure 9 below. The data from Figure 9 indicate that in a MOG 4 – 2 Shift operation, the manpower requirements decrease from the previous analyses to 84 personnel; 3,841 people less than the consolidated base at a total mean annual cost of approximately $144 million less than the consolidated base. This scenario would be slightly different from the other two in that the infrastructure requirements would be greater due to the enhanced maintenance and supply capability, and should be taken into consideration for this reason.

Figure 9: MOG 4 - 2 Shift Quick Comparison

Average Cost Analysis Compared to Workbook Analysis

Typically the Air Force models cost comparisons by using a very generic formula that incorporates the average pay of an officer and enlisted member on an annual basis. As defined by *AFI 65-503, US Air Force Cost and Planning Factors,* the average basic pay per officer per year amounts to $64,386 and for an enlisted service member, $31,398. For the purpose of a cost comparison, the annual pay per grade is used in this research. Table 8 demonstrates the use of the total mean annual pay per grade associated with the distributed network used for a MOG 4 – 2 Shift operation. It includes a total of 84 individuals required, broken down into 42 per base. Of these 42, 6 are officers and 36 are enlisted. Inherent to the formulation used, these personnel numbers are multiplied by the number of bases necessary to support the required aircraft transits per day. The annual mean total for the distributed network is equal to $3,296,169 for the 84 personnel. Table 9 depicts the numbers used for the same calculation but through the use of the average cost per officer and enlisted as identified by Appendix B generated from *AFI 65-503.* To calculate officer cost, six officers are multiplied by the average basic pay of $64,386 for a total of $386,316. To calculate enlisted costs, 36 are multiplied by the average basic pay of $31,398 for a total of $1,130,328. The total average annual basic pay for the distributed system with two bases is $3,033,288. Compared to the formulation used by the researcher, this number is $262,881 less than the more precise method used for the analyses within this research.

Table 9: Average Member Pay *(AFI 65-503)*

		Average Pay Per Base
# of Officers	6	
Avg. Officer Pay	$64,386	$386,316
# of Enlisted	36	
Avg. Enlisted Pay	$31,398	$1,130,328
Total Avg Pay/Base		$1,516,644
# of Bases		2

Expected Total Manning Cost of Distributed System		$3,033,288
Total # of Personnel	84	

Conclusion

The purpose of this workbook was not only to make this analysis possible, but to provide AMC with a tool to use in other studies. The pay sheets in the workbook are designed for quick and easy updates as pay table's change from year to year. Therefore, the workbook was developed to allow for easy updates of costs as new pay tables are enacted. In order to better depict the final calculations within this research, Table 10 provides a visual comparison of the three analyses and is presented in the next chapter.

V. Conclusions and Recommendations

Introduction

The focus of any research analysis is to provide answers to a topic that is otherwise unknown. The Air Force has utilized virtually the same en route support structure since its inception after World War II. With a changing environment and more constrained resources, innovative ideas are required to effectively sustain the war fighter on the front line in contingencies as well as providing support to the many humanitarian efforts needed worldwide. This chapter focuses on the conclusions and the recommendations of this research, as well as provides insight into possible future research ideas.

Conclusions

Chapter IV presented three different distributed network scenarios to compare manpower costs and physical infrastructure requirements (number of airfields) to the consolidated system prevalent in today's structure. Table 10 below provides a depiction of all the scenarios analyzed and the following subsections detail the advantages and disadvantages of the three scenarios.

Table 10: Analysis Comparison

	Consolidated Facility		
Scenario	Total # of Bases	Total # of Personnel	Total Mean Annual Cost
MOG 6 - 2 Shift	1	3,925	$147,189,808
	Distributed Network		
Scenario	Total # of Bases	Total # of Personnel	Total Mean Annual Cost
MOG 1 - 1 Shift	13	182	$7,189,646
MOG 1 - 2 Shift	7	196	$8,171,395
MOG 4 - 2 Shift	2	84	$3,296,169

MOG 1 – 1 Shift Operation Conclusion

The total personnel required to maintain the necessary throughput in this scenario is 182 individuals at a cost of $7,189,646. The personnel in this system would be split amongst 13 bases to operate on a single, 10 hour shift to support a MOG equal to one. While not the cheapest, this option would provide for a relatively small footprint with only 14 people at a particular base working for only 10 hours a day. This scenario would allow for a very limited presence at any one base, should that be requested by the host nation. Sustainment would be required for living purposes only, as the package would be predicated on a refuel only mission.

This particular scenario requires an extensive number of airfields to operate (more so than the other scenarios, at least) and therefore could pose potential problems with a host nation(s). On the margin, this scenario may actually cost more than the second scenario with the inclusion of opportunity costs, since the total number of bases is close to twice as many as the same MOG with a two-shift operation.

MOG 1 – 2 Shift Operation Conclusion

This particular scenario closely resembles the MOG 1 – 1 Shift operation, with an additional 14 people to total 196 people at a total cost of approximately $1 million more. Advantageously, the number of bases required to sustain the necessary throughput capability is decreased to seven bases. The operation would be a 20-hour workday, capable of more flexibility with aircraft arrivals. The presence of personnel at the seven bases would provide more capability and potential for manpower use if a particular aircraft requires additional resources. With the need for less physical infrastructure in this particular distributed network, the political approval of gaining access to a smaller number of airfields is easier to obtain. This is a particular advantage over the first scenario, as long as the host nation(s) is supportive of a two-shift operation with twice as many service members housed at a particular location.

A disadvantage of this system is the cost and the increased number of personnel in the event that the goal is to support en route refuel destinations with the minimum number of personnel at the lowest cost. The operation of two shifts also dictates a greater need for management at some level to schedule personnel, and the local airfield infrastructure must be capable of supporting this type of operation. From a more critical perspective, to reap the benefits of this scenario the necessary aspects of airfield operations, like weather and control tower operation, must operate during the necessary hours to support a two shift operation.

MOG 4 – 2 Shift Operation Conclusion

Discussed in previous chapters was the necessity of an analysis of a more enhanced distributed en route support system that provides a maintenance and supply element. This scenario actually provides the cheapest manpower cost with the least amount of airfields required for the necessary throughput. The package calls for 42 people per base to operate on a 20 hour basis. The total mean annual cost for manpower is under $4 million. The main advantage of this scenario is that it provides a bolstered presence to handle some of the many maintenance discrepancies that are possible, potentially saving money in transportation costs of support personnel in an otherwise scaled-down personnel requirement like that of the first two scenarios. This scenario also happens to be the cheapest option for total manpower cost, though it does increase the presence at a particular location.

With the presence of 42 personnel at a particular location that work for 20 hours per day, this would require a local infrastructure capable of supporting this large number of people with ground equipment and special parking considerations for maintenance work. This scenario would be limited to locations that are already large in terms of infrastructure and capability which may pose problems in obtaining the necessary agreements with a foreign state.

Recommendations

Given the three scenarios in this analysis, each has advantages and disadvantages that must be considered before a final decision is made. All three could pay huge dividends to the en route support system. If a distributed network is selected, the potential manpower savings are tremendous. The cheapest option is the enhanced MOG 4 – 2 Shift operation that includes a bolstered maintenance capability with the associated supply element. With only two bases required and 84 total personnel with a mean annual cost of only $3,296,169, the opportunity to take advantage of this scenario is apparent. If the decision maker wishes to provide only a refuel capability within the network, then the cheapest option would be a single shift operation with a MOG of one. More bases would be required, but the personnel associated would be less than that of a two shift operation and roughly $1 million cheaper. Given the office of sponsorship for this research the MOG 1 – 1 Shift operation would be the recommended network for a distributed system. The AMC/A9AA office was interested in a refuel only mission with a one shift operation. The MOG 1 – 1 Shift operation fulfills that interest, and the analysis conducted provided the comparison to that of the consolidated system. Although this distributed system includes the most bases, it provides the least amount of manning required per base at a reasonable annual cost. It simply is predicated upon a refuel only mission within a one shift per day time frame that makes for minimal infrastructure requirements aside from the number of bases in the system.

Future Research

There has been prior research in the realm of en route systems, specifically the research conducted by Sere and Voigt who have been mentioned throughout this analysis. This research sets a foundation for the costs associated with a distributed network of bases rather than the traditional consolidated system, but only analyzes the manpower costs. Future research opportunities exist in the other costs that would be associated with a distributed network, such as contract costs with host nations. A large assumption in this sort of network of facilities is that aircraft land and takeoff on schedule with no maintenance discrepancies. A computer simulation could be accomplished to take break rates into account, as well as unscheduled maintenance events for transport aircraft. This simulation could incorporate a 13-base network of distributed bases like that of the MOG 1 – 1 Shift operation scenario presented in this analysis, and in addition, should examine the likelihood of maintenance discrepancies and the frequency at which these would occur. An analysis of this area could prove beneficial in the selection of what type of distributed network should be selected, such as the MOG 4 – 2 Shift operation presented in this research.

Appendix A: Ground Times

Aircraft Type	Passenger and Cargo Operations Wartime Planning Times (hrs+min)				Minimum Crew Rest Times	Aeromedical Evacuation (hrs+min)		
	Onload	En route Refuel only	Offload	Expedited[2]		Reconfigure	Onload/ Offload	Expedited[2]
C-9	-	-	-	-	15+45	1+30	1+30	45
C-130	2+15	1+30	2+15	0+45	16+15	1+30	1+30	45
C-141	3+15	2+15	3+15	1+15	16+00	4+00	2+15	1+15
C-17	3+15	2+15	3+15	1+45	16+30	4+15	2+15	1+45
C-5	4+15	3+15	4+15	2+00	17+00	-	-	-
KC-10	4+15	3+15	4+15	3+15	17+00	-	-	-
KC-135[3]	4+15	3+15	4+15	3+15	17+00	1+30	1+30	45
B-747	3+30/5+00[1]	1+30	3+30/5+00[1]	-	-	-	-	-
B-707	3+00	1+30	3+00	-	-	-	-	-
B-767	3+00	1+30	3+00	-	-	n/a	5+00	5+00
DC-8	2+30/ 3+30[1]	1+30	2+30/ 3+30[1]	-	-	-	-	-
DC-10	2+30/5+00[1]	1+30	2+30/5+00[1]	-	-	-	-	-
L-1011	2+30/5+00[1]	1+30	2+30/5+00[1]	-	-	-	-	-
MD-11	3+30/ 5+00[1]	1+30	3+30/ 5+00[1]	-	-	-	-	-

NOTES:

1. Passenger/Cargo.
2. Onload or offload operations only. Does not include refuel or reconfiguration operations.
3. KC-135 times apply to roller-equipped aircraft.

Appendix B: Military Pay Rates per Unit of Time

FY 2010

MILITARY ANNUAL STANDARD COMPOSITE PAY

BASED ON PRESIDENT'S BUDGET

GRADE	BASIC PAY*	MEDICARE-ELIGIBLE HEALTH CARE ACCRUAL	RETIRED PAY ACCRUAL	BAH	Subsistence	INCENTIVE SPECIAL PAY	PCS	MISCEL-LANEOUS	TOTAL ANNUAL COMPOSITE RATE	ACCLERATION FACTOR	AMT BILLABLE TO NON-DOD ENTITIES
OFFICER											
O-10	$181,231	$5,642	$58,538	$24,190	$2,799	$8,408	$6,338	$14,024	$301,170	$9,586	$305,114
O-9	$179,472	$5,642	$57,972	$27,648	$2,799	$8,408	$6,338	$13,663	$301,942	$9,586	$305,886
O-8	$157,030	$5,642	$50,720	$25,507	$2,799	$8,408	$6,338	$13,378	$269,822	$9,586	$273,766
O-7	$136,231	$5,642	$44,000	$23,780	$2,799	$8,408	$6,338	$13,612	$240,810	$9,586	$244,754
O-6	$113,778	$5,642	$36,494	$24,259	$2,799	$8,408	$6,338	$12,919	$210,637	$9,586	$214,581
O-5	$92,720	$5,642	$29,740	$23,344	$2,799	$8,408	$6,338	$11,382	$180,373	$9,586	$184,317
O-4	$78,371	$5,642	$25,138	$22,031	$2,799	$8,408	$6,338	$9,966	$158,693	$9,586	$162,637
O-3	$63,380	$5,642	$20,329	$18,574	$2,799	$8,408	$6,338	$8,619	$134,089	$9,586	$138,033
O-2	$48,620	$5,642	$15,703	$15,012	$2,799	$8,408	$6,338	$6,744	$109,266	$9,586	$113,210
O-1	$34,569	$5,642	$11,165	$12,395	$2,799	$8,408	$6,338	$5,192	$86,508	$9,586	$90,452
TOTAL AVERAGE	$64,386	$5,642	$22,578	$19,482	$2,799	$8,408	$6,338	$9,094	$138,727	$9,586	$142,671
CADETS	$11,396	$5,642			$3,719		$177	$872	$21,806		$16,164
ENLISTED											
E-9	$70,367	$5,642	$22,599	$17,524	$4,017	$1,570	$3,123	$9,052	$133,894	$9,586	$137,838
E-8	$57,275	$5,642	$18,394	$16,492	$4,017	$1,570	$3,123	$8,086	$114,599	$9,586	$118,543
E-7	$48,781	$5,642	$15,666	$16,096	$4,017	$1,570	$3,123	$7,140	$102,035	$9,586	$105,979
E-6	$39,633	$5,642	$12,728	$15,054	$4,017	$1,570	$3,123	$6,154	$87,921	$9,586	$91,865
E-5	$31,596	$5,642	$10,147	$13,117	$4,017	$1,570	$3,123	$5,329	$74,541	$9,586	$78,485
E-4	$25,291	$5,642	$8,169	$9,823	$4,017	$1,570	$3,123	$4,356	$61,991	$9,586	$65,935
E-3	$20,588	$5,642	$6,650	$4,385	$4,017	$1,570	$3,123	$3,696	$49,671	$9,586	$53,615
E-2	$19,235	$5,642	$6,213	$2,586	$4,017	$1,570	$3,123	$3,207	$45,593	$9,586	$49,537
E-1	$16,478	$5,642	$5,323	$1,635	$4,017	$1,570	$3,123	$2,658	$40,446	$9,586	$44,390
TOTAL AVERAGE	$31,398	$5,642	$10,102	$10,870	$4,017	$1,570	$3,123	$5,090	$71,812	$9,586	$75,756

Appendix C: Dover AFB, DE Unit Manning Document (as of Dec 2009)

GRADE	*OFF*	*ENL*	*CIV*	*10/4 TOTAL*
COL	6			6
LTCOL	40			40
MAJOR	51			51
CAPT	109			109
LT	86			86
CMSGT		22		22
SMSGT		39		39
MSGT		252		252
TSGT		461		461
SSGT		754		754
SRA		682		682
A1C		721		721
YC-03			1	1
YC-02			31	31
YC-01			7	7
YA-02			48	48
YB-02			5	5
YB-01			2	2
YF-03			1	1
YF-02			8	8
YD-02			10	10
YD-01			1	1
YH-02			7	7
YN-01			9	9
YM-01			17	17
GS-12			3	3
GS-11			34	34
GS-10			4	4
GS-09			69	69
GS-08			12	12
GS-07			40	40
GS-06			14	14
GS-05			47	47
GS-04			59	59
GS-03			5	5
WS-15			1	1
WS-14			1	1
WS-12			1	1
WS-11			5	5
WS-10			5	5
WS-09			9	9
WS-08			10	10
WS-07			1	1
WS-06			3	3
WS-05			1	1
WS-04			4	4
WS-03			1	1
WL-10			12	12
WL-08			6	6
WG-12			14	14
WG-11			10	10
WG-10			87	87
WG-09			9	9
WG-08			27	27
WG-07			12	12
WG-06			15	15
WG-05			7	7
WG-03			2	2
TBD			27	27
Report Total	**292**	**2931**	**704**	**3927**

Appendix D: 2010 Military Pay Scale

BASIC PAY—EFFECTIVE JANUARY 1, 2010											
Pay Grade	2 or less	Over 2	Over 3	Over 4	Over 6	Over 8	Over 10	Over 12	Over 14	Over 16	Over 18
O-10[2]											
O-9											
O-8	9399.00	9706.80	9911.10	9968.40	10223.40	10649.10	10748.40	11152.80	11268.60	11617.20	12121.20
O-7	7809.90	8172.90	8340.60	8474.10	8715.60	8954.40	9230.40	9505.50	9781.80	10649.10	11381.40
O-6	5788.50	6359.40	6776.70	6776.70	6802.50	7094.10	7132.50	7132.50	7537.80	8254.80	8675.40
O-5	4825.50	5436.00	5812.50	5883.30	6117.90	6258.60	6567.60	6794.10	7086.90	7535.10	7748.10
O-4	4163.70	4819.80	5141.40	5213.10	5511.60	5831.70	6230.10	6540.60	6756.60	6880.20	6951.90
O-3	3660.60	4149.90	4479.30	4883.40	5117.10	5373.90	5540.10	5813.40	5955.60	5955.60	5955.60
O-2	3162.90	3602.40	4149.00	4289.10	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30
O-1	2745.60	2857.50	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20
O-3[3]				4883.40	5117.10	5373.90	5540.10	5813.40	6043.50	6175.80	6355.80
O-2[3]				4289.10	4377.30	4516.80	4752.00	4933.80	5069.10	5069.10	5069.10
O-1[3]				3454.20	3688.80	3825.00	3964.80	4101.60	4289.10	4289.10	4289.10
W-5											
W-4	3783.00	4069.50	4186.50	4301.10	4499.10	4695.00	4893.00	5191.80	5453.40	5702.10	5905.50
W-3	3454.50	3598.50	3746.10	3794.70	3949.50	4254.00	4571.10	4720.20	4892.70	5070.90	5390.40
W-2	3057.60	3346.20	3435.30	3496.50	3694.80	4002.90	4155.30	4305.90	4489.50	4633.20	4763.40
W-1	2683.50	2971.80	3049.80	3213.90	3408.30	3694.20	3827.70	4014.30	4197.90	4342.20	4475.40
E-9[4]							4570.80	4674.30	4804.80	4958.40	5112.90
E-8						3741.60	3907.20	4009.50	4132.50	4265.40	4505.40
E-7	2601.00	2838.90	2947.50	3091.80	3204.00	3396.90	3505.50	3699.00	3859.50	3969.00	4085.70
E-6	2249.70	2475.30	2584.50	2690.70	2801.40	3051.00	3148.20	3336.00	3393.60	3435.60	3484.50
E-5	2061.30	2199.30	2305.50	2414.40	2583.90	2761.80	2908.70	2924.70	2924.70	2924.70	2924.70
E-4	1889.70	1986.30	2094.00	2199.90	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80
E-3	1705.80	1813.20	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00
E-2	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10
E-1[5]	1447.20										

Appendix D: 2010 Military Pay Scale (Continued)

BASIC PAY—EFFECTIVE JANUARY 1, 2010

Pay Grade	Over 20	Over 22	Over 24	Over 26	Over 28	Over 30	Over 32	Over 34	Over 36	Over 38	Over 40
O-10[2]	15188.10	15262.20	15579.60	16132.50	16132.50	16939.20	16939.20	17785.80	17785.80	18675.30	18675.30
O-9	13283.70	13475.10	13751.40	14233.80	14233.80	14946.00	14946.00	15693.30	15693.30	16477.80	16477.80
O-8	12506.20	12896.70	12896.70	12896.70	12896.70	13219.20	13219.20	13549.80	13549.80	13549.80	13549.80
O-7	11381.40	11381.40	11381.40	11439.30	11439.30	11668.20	11668.20	11668.20	11668.20	11668.20	11668.20
O-6	9095.70	9334.80	9577.20	10047.00	10047.00	10247.70	10247.70	10247.70	10247.70	10247.70	10247.70
O-5	7959.00	8198.40	8198.40	8198.40	8198.40	8198.40	8198.40	8198.40	8198.40	8198.40	8198.40
O-4	6951.90	6951.90	6951.90	6951.90	6951.90	6951.90	6951.90	6951.90	6951.90	6951.90	6951.90
O-3	5955.60	5955.60	5955.60	5955.60	5955.60	5955.60	5955.60	5955.60	5955.60	5955.60	5955.60
O-2	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30	4377.30
O-1	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20	3454.20
O-3[1]	6355.80	6355.80	6355.80	6355.80	6355.80	6355.80	6355.80	6355.80	6355.80	6355.80	6355.80
O-2[1]	5069.10	5069.10	5069.10	5069.10	5069.10	5069.10	5069.10	5069.10	5069.10	5069.10	5069.10
O-1[1]	4289.10	4289.10	4289.10	4289.10	4289.10	4289.10	4289.10	4289.10	4289.10	4289.10	4289.10
W-5	6726.60	7068.00	7322.10	7603.50	7603.50	7983.90	7983.90	8383.20	8383.20	8802.60	8802.60
W-4	6104.10	6396.00	6635.40	6909.00	6909.00	7047.00	7047.00	7047.00	7047.00	7047.00	7047.00
W-3	5606.70	5736.00	5873.40	6060.00	6060.00	6060.00	6060.00	6060.00	6060.00	6060.00	6060.00
W-2	4918.80	5021.40	5102.70	5102.70	5102.70	5102.70	5102.70	5102.70	5102.70	5102.70	5102.70
W-1	4636.80	4636.80	4636.80	4636.80	4636.80	4636.80	4636.80	4636.80	4636.80	4636.80	4636.80
E-9[1]	5361.60	5571.30	5792.40	6129.90	6129.90	6436.20	6436.20	6758.40	6758.40	7096.50	7096.50
E-8	4626.90	4833.90	4948.50	5231.40	5231.40	5336.40	5336.40	5336.40	5336.40	5336.40	5336.40
E-7	4131.30	4282.80	4364.40	4674.60	4674.60	4674.60	4674.60	4674.60	4674.60	4674.60	4674.60
E-6	3404.50	3404.50	3404.50	3404.50	3404.50	3404.50	3404.50	3404.50	3404.50	3404.50	3404.50
E-5	2924.70	2924.70	2924.70	2924.70	2924.70	2924.70	2924.70	2924.70	2924.70	2924.70	2924.70
E-4	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80	2293.80
E-3	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00	1923.00
E-2	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10	1622.10

Appendix E: General Schedule Pay Scale

SALARY TABLE 2010-GS
INCORPORATING THE 1.50% GENERAL SCHEDULE INCREASE

EFFECTIVE JANUARY 2010

Annual Rates by Grade and Step

Grade	Step 1	Step 2	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8	Step 9	Step 10	WITHIN GRADE AMOUNTS
1	$ 17,803	$ 18,398	$ 18,990	$ 19,579	$ 20,171	$ 20,519	$ 21,104	$ 21,694	$ 21,717	$ 22,269	VARIES
2	20,017	20,493	21,155	21,717	21,961	22,607	23,253	23,899	24,545	25,191	VARIES
3	21,840	22,568	23,296	24,024	24,752	25,480	26,208	26,936	27,664	28,392	728
4	24,518	25,335	26,152	26,969	27,786	28,603	29,420	30,237	31,054	31,871	817
5	27,431	28,345	29,259	30,173	31,087	32,001	32,915	33,829	34,743	35,657	914
6	30,577	31,596	32,615	33,634	34,653	35,672	36,691	37,710	38,729	39,748	1019
7	33,979	35,112	36,245	37,378	38,511	39,644	40,777	41,910	43,043	44,176	1133
8	37,631	38,885	40,139	41,393	42,647	43,901	45,155	46,409	47,663	48,917	1254
9	41,563	42,948	44,333	45,718	47,103	48,488	49,873	51,258	52,643	54,028	1385
10	45,771	47,297	48,823	50,349	51,875	53,401	54,927	56,453	57,979	59,505	1526
11	50,287	51,963	53,639	55,315	56,991	58,667	60,343	62,019	63,695	65,371	1676
12	60,274	62,283	64,292	66,301	68,310	70,319	72,328	74,337	76,346	78,355	2009
13	71,674	74,063	76,452	78,841	81,230	83,619	86,008	88,397	90,786	93,175	2389
14	84,697	87,520	90,343	93,166	95,989	98,812	101,635	104,458	107,281	110,104	2823
15	99,628	102,949	106,270	109,591	112,912	116,233	119,554	122,875	126,196	129,517	3321

Appendix F: Wx Pay Scale

AC-0026R DoD Civilian Personnel Management Service (AW)
Arlington, Virginia 22209-5144 Issue Date: 13 January 2009

SUBJECT: Federal Wage System Regular and Special Production Facilitating Wage Rate Schedules for the Wilmington, Delaware (DCB) Wage Area

TO: Commanding Officers of Military Departments and DoD Component Installations in the Area

The schedules shown below have been established under authority of DoD Instruction 5120.39, dated September 10, 2008, subject to the limitations contained in CPM 2008-23, dated 18 December 2008. Rates are established as required by 5 USC 5343(d), if applicable, and are to be applied in accordance with the provisions of 5 CFR Part 532 to all employees whose official duty station is located within the geographic boundary of the wage area definition shown on the reverse side.

WG WL-WS Grade	WG-Rates 1	2	3	4	5	WL-Rates 1	2	3	4	5	WS-WD-WN Rates 1	2	3	4	5	WD-WN Pay Level	
1	12.84	13.37	13.90	14.44	14.99	14.12	14.72	15.30	15.88	16.47	20.43	21.29	22.16	22.98	23.84		
2	14.33	14.93	15.50	16.11	16.71	15.74	16.40	17.05	17.71	18.37	21.91	22.84	23.74	24.65	25.56		
3	15.78	16.43	17.09	17.74	18.40	17.36	18.08	18.79	19.50	20.23	23.37	24.35	25.31	26.29	27.27	1	
4	17.23	17.96	18.68	19.39	20.11	18.96	19.75	20.55	21.33	22.10	24.85	25.88	26.91	27.93	28.98	2	
5	18.71	19.48	20.28	21.06	21.84	20.59	21.44	22.30	23.16	24.02	26.30	27.40	28.49	29.61	30.70	3	
6	20.16	21.02	21.86	22.70	23.54	22.21	23.13	24.04	24.96	25.89	27.78	28.92	30.09	31.26	32.40	4	
7	21.57	22.47	23.35	24.26	25.17	23.73	24.71	25.69	26.68	27.67	29.18	30.38	31.60	32.82	34.02	5	1
8	22.62	23.56	24.50	25.46	26.39	24.69	25.91	26.94	27.96	29.02	30.20	31.46	32.73	34.00	35.25	6	2
9	23.80	24.79	25.77	26.78	27.81	26.16	27.23	28.35	29.41	30.55	31.21	32.54	33.91	35.18	36.46	7	3
10	24.76	25.79	26.79	27.88	28.89	27.22	28.35	29.46	30.61	31.77	32.24	33.53	34.91	36.27	37.61	8	4
11	25.66	26.74	27.86	28.95	30.01	28.25	29.47	30.64	31.85	33.01	33.01	34.38	35.75	37.13	38.52	9	5
12	26.65	27.78	28.87	29.99	31.15	29.29	30.55	31.80	32.98	34.21	34.03	35.47	36.92	38.34	39.75	10	6
13	27.58	28.73	29.85	31.05	32.21	30.32	31.59	32.91	34.09	35.36	35.27	36.75	38.23	39.70	41.15	11	7
14	28.49	29.72	30.88	32.07	33.30	31.38	32.68	34.02	35.29	36.66	36.41	37.94	39.43	40.95	42.46		8
15	29.45	30.68	31.96	33.16	34.38	32.40	33.80	35.20	36.53	37.88	37.70	39.29	40.85	42.41	44.00		9
WS-16											39.19	40.83	42.46	44.09	45.73		
WS-17											40.86	42.56	44.26	45.96	47.67		
WS-18											42.72	44.49	46.27	48.06	49.84		
WS-19											40.94	42.65	44.36	46.06	47.77		

R. CRAIG JERABEK
Chief
Wage and Salary Division

Order Date: 4 November 2008
Effective Date: 18 January 2009
Supersedes Schedule Issued 15 January 2008

Appendix G. Blue Dart

Manpower Cost Analysis of a Consolidated and a Distributed En Route Support System

"Simply put, we have three wartime mission objectives: Get the war fighter to the fight, Sustain the war fighter during the fight, Bring the war fighter home after the fight."

-
- John Handy, General, USTRANSCOM/CC, 2004

In a broad sense, the above objectives remain unchanged since the inception of the Air Force. But what has changed is the environment with which we transport and sustain our war fighters, and to that end our strategy must also change. For a vast amount of time in the Air Force's history, we were postured to fight the Cold War. And we built up a global presence because of it that included as many as 45 en route support airfields with vast amounts of infrastructure and manpower to coincide. But when the Cold War ended and a new threat began to arise, our strategy needed a serious reconstruction.

The last true war fought against another state was Desert Storm in the early 1990s when Saddam Hussein's name became common around the dinner table. Since, the major conflicts we have fought in have been against a "stateless" organization with a highly generalized description as "The War on Terror". With that, a leaner and agile warfighting requirement has developed where manpower cuts have been common place and infrastructure draw-downs throughout the world have occurred. Those 45 en route bases we once occupied have since been reduced to only 13. The core tenet of flexibility has become threatened.

While numerous studies have been accomplished on the en route system, most have focused on the same strategy of optimal location and base selection similar to what we as an organization have always done. This research focused on the new concept of a distributed network of en route support bases, where a certain required number of smaller bases are used instead of one of the 13 larger bases we currently have. The analysis was completed with the requirement that the aircraft transits per day from a base such as Ramstein AB, Germany was equal to the total number of aircraft transits per day from the smaller, distributed bases. Could the Air Force posture an en route support system with minimal manning at already existing airfields with inherent infrastructure and personnel? This research identified a new possibility in en route structures by identifying the Unit Type Codes necessary to support a refuel only mission at an en route location that allows for minimal manning and a smaller, more flexible infrastructure.

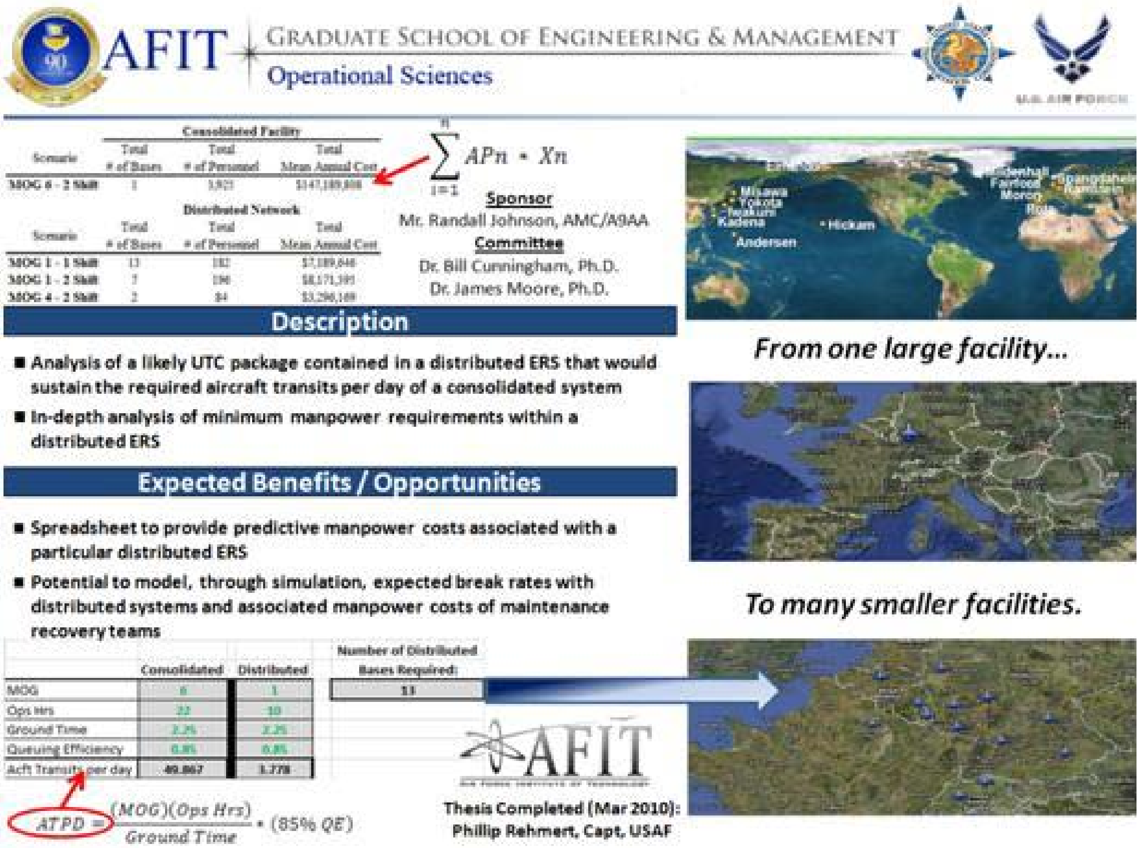
Though further research is required, this analysis potentially identified huge savings in manpower costs. Specifically, the manpower used in a distributed network

Appendix G. Blue Dart (Continued)

could utilize approximately 3,600 fewer people with savings of well over $130 million per year. The advantage this distributed network has is that the locations of these bases utilize previously existing personnel and infrastructure from a particular host nation. This allows for a much smaller contingent of personnel that support only the function of the en route strategy selected. This research chose to focus on a refuel only strategy, as well as a very basic maintenance package to coincide with the refuel mission. The primary concern is that the necessary aircraft transits required to support the war fighter is equal to that of the consolidated base. The formulation used in this analysis calculates the necessary aircraft transits and builds a network of bases to support it.

This research provides another way to envision a global network of en route support bases; a potential to save millions of dollars in a time of budgetary constraints. We must continue to have the capability to fly, fight, and win, but also we must continue to find efficient, yet effective means in which to sustain our valuable men and women on the front lines.

Appendix H. Quad Chart



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Vita

Captain Phillip M. Rehmert graduated from Union City High School in Union City, Tennessee in May, 2000. He attended Middle Tennessee State University and graduated with a degree in Aerospace in May of 2004, cum laude. He was commissioned through the Reserve Officer Training Corps.

His first assignment was at Seymour Johnson AFB as a maintenance officer for the 4 Maintenance Group, 4 Fighter Wing and held positions in the Maintenance Operations Squadron, Aircraft Maintenance Squadron, Equipment Maintenance Squadron, and Component Maintenance Squadron. In August of 2008, he entered the Graduate School of Engineering and Management, Air Force Institute of Technology. Upon graduation, he will be assigned to the Air Force Logistics Management Agency, Gunter Annex, Maxwell AFB, Alabama.

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14. ABSTRACT

The United States military has developed an en route support structure for airlift requirements to deploy and sustain combat forces in conflict. The Air Mobility Command (AMC) is interested in determining the cost effectiveness of two distinctly different en route structures, in particular, the cost effectiveness of one large facility versus supporting combat forces with many smaller facilities. With the current operational tempo, continued analysis must be accomplished to determine if a smaller footprint is possible in the deployment and sustainment scenarios of conflicts seen today; conflicts more centered on a leaner and faster deployment force. This research examines the requirements of manpower needed to support a network of one large facility and compares the data with the same information for a network of many smaller facilities. The number of required airfields in a distributed network must be determined to examine the manpower cost structure associated with the distributed network; therefore the number of airfields becomes a cornerstone to which the cost analysis is predicated upon. The effectiveness of both systems will be measured in aircraft transits per day with the cost measured in annual manpower costs.

15. SUBJECT TERMS
Consolidated En Route Support System, Distributed En Route Support System, Unit Type Code, Maximum On Ground (MOG), Manpower, Throughput Capability, Aircraft Transits per Day

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